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STRIPE RUST IN ALBERTA*

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A note on the incidence of stripe rust, *Puccinia glumarum* (Schm.) Erikss. & Henn., in Alberta, will be of interest to those following the distribution of this rust in North America, or particularly in Western Canada. During August and September of 1928, stripe rust was found quite easily in many parts of Alberta. This includes the Grande Prairie district of Alberta, and the adjacent Pouce Coupé district of British Columbia in the Peace River block. The first case of stripe rust in Western Canada was recorded by Fraser (*2*) in 1918, it being found on *Hordeum jubatum*, at Edmonton, Alberta. The first collection of stripe rust on wheat in Western Canada was made at Olds, by Sanford (*6*), this rust being found on the leaves, glumes and awns of several varieties of wheat, as well as on the leaves of *H. jubatum* which grew near by. No search for stripe rust was made elsewhere in Alberta in 1926. In 1927 Sanford (*7*) again collected stripe rust on a number of varieties of wheat, and also on *H. jubatum* at the Provincial School of Agriculture, Olds, Alberta. Later in the same season the rust was observed in a field of wheat south-east of Cardston, in the extreme south of Alberta, and it was also observed on *H. jubatum* which grew in a low place near the rusted wheat. In a local area of the field near Cardston the rust was plentiful on the succulent leaves of the wheat, but not on the glumes. No special search was made for stripe rust in 1927, and it is possible that it escaped notice in parts of Alberta. Johnson and Newton (*5*) reported a collection of it on *H. jubatum* at Edmonton in 1927. In 1928 a more careful search was made for stripe rust than had been previously attempted. The result was that *P. glumarum* was collected on wheat, common barley, *H. jubatum* and on species of the Agropyrons at many localities throughout Alberta.

STRIPE RUST IN ALBERTA IN 1928

By August 14 stripe rust had been found on *H. jubatum* at many widely distributed points in Alberta, from the foot hills of the Rocky Mountains east to the Saskatchewan boundary; and from the Grand Prairie and Pouce Coupé districts of the Peace River area in the north, to the Lethbridge district in the south. Previous to August 14, it appeared that stripe rust could be found on wild barley only in low, cool, wet places, but subsequently it became plentiful on wild barley growing on the higher ground in fields and along roadsides. This rust seemed to increase gradually on the wild barley until the end of September, when frost checked the vegetation.

*Contribution from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Ont., Canada.

Stripe rust was frequently observed on wild barley in wheat fields, but in these cases the wheat apparently escaped infection, which might indicate that the variety of wheat was resistant to the form on the wild barley. In addition to the stripe rust found on winter wheat on May 12 at Claresholm, and on spring sown wheat later at Olds, it was collected in September on spring wheat, on O. A. C. 21 barley, at the Dominion Irrigation Station Brooks, and also on seedlings of fall sown wheat, (Kharkov M. C. 22) at Claresholm, as well as in fields of fall sown winter wheat in the Pincher Creek and Cowley districts. It was also found on a smooth awn hybrid of common barley at Claresholm late in September. Hungerford and Owens (*4*), and others report that stripe rust goes to *Agropyron tenerum*. Infection was not observed on this species, although this grass often grew among wild barley plants severely rusted. Stripe rust appeared on *A. smithii* at points in Southern Alberta, where this grass is general.

A summary of the collections of stripe rust made in Alberta in 1928 is presented in Table 1, and graphically represented on the map in Figure 1.

TABLE 1. *Incidence of Puccinia glumarum in Alberta and British Columbia, 1928.*

Date 1928	Locality	Host	Location of Host
May 8	Claresholm	*Triticum vulgare*, var. Kharkov M.C. 22.	Experimental plots.
" 8	Barons	"	Wheat fields
" 8	Nobleford	"	" "
June 1	Claresholm	"	" "
July 2	Beaverlodge	*Hordeum jubatum*	Low place.
" 3	Rolla, B. C.	" "	" "
" 3	Pouce Coupé, B.C.	" "	" "
Aug. 7	Wetaskiwin	" "	" "
" 7	"	" "	Wheat fields.
" 9	Olds	" "	Experimental ground fence.
" 9	"	*Triticum spp.* (for varieties see Table 3).	Experimental plots.
" 9	Carstairs	*Hordeum jubatum*	Low and moist.
" 9	Crossfield	" "	In field of Marquis wheat.
" 10	Kananaskis	" "	Rocky Mt. Park, near standing water.
" 10	Morley	" "	Near standing water in ditch.
" 11	High River	" "	Low and moist.
" 11	Staveley	" "	" "
" 11	Granum	" "	" "
" 11	Lethbridge	" "	Edge of irrigation ditch.
" 12	Monarch	" "	Low and moist.
" 12	Edgerton	" "	" "
" 15	Camrose	" "	" "
" 15	Kitscoty	" "	" "
" 16	Daysland	" "	" "
" 16	Vegreville	" "	" "
" 16	Killam	" "	" "
" 16	Czar	" "	" "
" 16	Amisk	" "	" "
" 17	Provost	" "	" "
" 17	Bruderheim	" "	" "
" 17	Compeer	" "	" "
" 17	Kirriemuir	" "	" "
" 17	Monitor	" "	" "
" 17	Consort	" "	" "
" 18	Castor	" "	" "
" 18	Stettler	" "	" "
" 18	Alix	" "	" "
" 18	Mirror	" "	" "
" 21	Lacombe	" "	" "
" 22	Strathmore	" "	" "

Date 1928	Locality	Host	Location of Host
Aug. 23	Brooks	*Hordeum vulgare* var. O.A.C. 21.	Experimental plots, irrigated.
" 23	Gleichen	*Hordeum jubatum*	Low and moist.
" 24	Enchant	" "	Ditches and fields.
" 24	Vauxhall	" "	Roadsides.
" 25	Taber	" "	By irrigation ditch.
" 25	Coaldale	" "	" " "
" 25	Lethbridge	" "	" " "
" 25	Monarch	" "	Low place.
" 25	Calgary	" "	Edge of slough.
" 27	Raymond	" "	" "
" 28	Didsbury	*Hordeum vulgare* var. O.A.C. 21	" "
" 29	Innisfail	*Hordeum jubatum*	Roadside, trace.
Sept. 20	Nanton	" "	Roadside and fields, (plentiful)
" 20	"	*Agropyron smithii*	" " "
" 20	Staveley	*Hordeum jubatum*	" " "
" 20	"	*Agropyron spp.*	Roadside (plentiful)
" 21	Claresholm	*Triticum vulgare*, Kharkov (winter wheat)	Experimental plots, "
" 21	"	*Hordeum jubatum*	Fence near experimental plots. "
" 21	"	*Hordeum vulgare*	Experimental plots, "
" 21	Granum	*Agropyron smithii*	Roadside, "
" 21	"	*Agropyron dasystachyum*	" "
" 22	Cowley	*Hordeum jubatum*	" "
" 22	Pincher Creek	*Triticum vulgare*, Turkey Red (winter wheat)	Field "
" 22	Waterton Lakes	*Hordeum jubatum*	Roadside "
" 22	Cardston	" "	" "
" 22	Hillspring	" "	" "
" 22	Glenwood	" "	" "
Oct. 1	Edmonton	" "	" "
" 5	E. Strathcona	" "	Farmyard "
" 18	Cooking Lake	" "	Roadside "

Many more collections could have been listed, but from those given it is clear that stripe rust was very generally distributed in Alberta in 1928. From Table 1, the impression is that, previous to the middle of August, stripe rust seemed to develop best in low, damp places on wild barley, and that later conditions were favourable for its spread almost anywhere.

The question naturally arises whether stripe rust has been general on wild barley in Alberta in previous seasons, and has escaped notice. It is quite possible that this might be the case, since the survey in 1928 was the first time that more than casual search had been made for this rust during a season. At any rate, stripe rust has apparently never been severe enough on wheat in Alberta to attract attention. In this connection, the relative susceptibility of the varieties of wheat given in Table 2 is very interesting. Of the 64 varieties of spring wheat, planted in duplicate, and distributed, only Chagot developed severe foliage infection. The severity of infection on the leaves of the remaining varieties varied from zero to not more than a trace, or in one case on White Federation, only medium infection. Fifty-three of these varieties are classed as having no rust, while nine varieties had a trace. The varieties having a trace of stripe rust are Bunyip, Early Baart, Bishop, Kubanka, Vermilion, Early Red Fife, Washington 143, Prelude and Early Java.

TABLE 2. *The reaction of 64 varieties of wheat to Puccinia glumarum at the Provincial School of Agriculture, Olds, Alberta, August, 1928.*

Variety*	Replicate	
	A	B
Garnet	0	0
Ruby	0	0
Reward	0	0
Bobs 222	0	0
Quality 1	0	0
Chagot	severe	severe
Sunset Cal. 3015	0	0
Red Bobs	0	0
" " Supreme	0	0
" " Early Triumph	0	0
Hard Federation C. 14733	0	0
S. W. 1-23	0	0
White Federation Cal. 3213	trace	medium
Bunyip Cal. 3203	trace	trace
Marquis	0	0
" 10B	0	0
" Grenville	0	0
" 7	0	trace
Monad CI 3220	0	0
Early Baart Cal. 3929	trace	trace
Velvet Chaff	0	0
Percy	0	0
Red Chaff	0	0
Pioneer	0	0
Preston	0	0
Bishop	trace	trace
Fisher 1	0	0
Red Club	0	0
Khahla MAC 22	0	0
Kubanka	0	0
" Erickson	0	trace
Mindum	0	0
Black BD	0	0
Vermilion	trace	trace
Fisher 2	0	0
Red Fife	0	0
Early Red Fife Ottawa 16	trace	trace
Kitchener	0	0
Red Russian	0	0
Stanley	0	0
Polish	0	0
Acme 1	0	0
Defiance	0	0
Huron	0	0
E. Java	trace	0
Speltz	0	0
Wash. 143	trace	trace
Blue Stem	0	0
Kobben	0	0
Egyptian	0	0
Emmer	0	0
Ceres (Wills)	0	0
Supreme (Glacier)	0	0
Duchess	0	0
Major	0	0
Producer B	0	0
Aurora	0	0
Producer A	0	0
Axminster	0	0
Marquillo	0	0
Prelude	trace	trace
Acme 1	0	0
S. W. 1-22	0	0
Einkorn	0	0

*Information on origin of varieties kindly supplied by Mr. A. T. Kemp, School of Agriculture, Olds, Alberta.

If conditions of the environment were equally favorable for the development of stripe rust on all the varieties listed in Table 2, (and there appears to be no reason why these should not have been uniform,) several tentative deductions may be made from the results in this table. First, judging from the uniform severity of stripe rust on both plots of Chagot, an abundance of inoculum of *P. glumarum* must have been distributed over the entire area of the varietal test, thus giving each variety a reasonable chance to indicate its resistance to the form or forms of stripe rust prevailing. Secondly the inoculum was apparently air borne, because at the time severe infection appeared on the Chagot plots, only a trace of stripe rust was found on wild barley elsewhere in Alberta. Further, most of our commonly grown wheat varieties are resistant, or only slightly susceptible to the prevailing strains of stripe rust and, therefore, this would undoubtedly help to explain why stripe rust has not become a serious menace in Western Canada. Obviously, further work on the specialization of the forms of stripe rust in Alberta is needed.

Over-Wintering of Stripe Rust

It is a question whether *P. glumarum* over-winters on its hosts in Alberta, and also whether, as appears probable with stem rust of wheat and oats, each season's main infection originates from air borne spores coming from outside regions. Hungerford (*4*) concludes from his experiments that stripe rust can easily over-winter in the uredinial stage, and as mycelium in wheat and wild barley plants in the Pacific Coast area. Willis (*8*) states that he had good evidence that mycelium of stripe rust may over-winter at Moscow, Idaho, on *H. jubatum* and *Bromus marginatus*. Several authors in European countries state that *P. glumarum* over-winters in Europe. Biffin (*1*) found that the spores of stripe rust on wheat plants remained readily viable throughout the winter in England, and that the rust would develop with great rapidity in early spring on leaves of these plants. Hecke (*3*) observed that stripe rust would develop in the spring from old spots on the leaves infected the preceding autumn, and that in about two weeks a second infection developed on the new leaves of these infected plants.

Our observations leave little room for doubt that stripe rust can over-winter in Alberta under winter conditions of average severity. On May 12, stripe rust was observed to be fairly plentiful on the first, second and third leaves of some plants of winter wheat, variety Kharkov. M. C. 22, on the experimental plots at the Provincial School of Agriculture, Claresholm. Spore material was taken from the first, second and third leaves for viability tests. Each lot of spores was tested on the surface of distilled water, and a high percentage of germination was obtained from all collections. Another viability test of the spores was made again in July, but only an occasional spore germinated at this time. Hungerford (*5*) states that after 58 days he obtained some germination of urediniospores from rusted material kept in herbarium packets at room temperature.

The first and second leaves were usually more or less chlorotic, but sometimes green. These leaves belonged to the 1927 growth, and were rusted that season. The rusted third leaves, which were of a bright green colour, probably belonged partly to the 1927 growth and partly to the early

FIGURE 1. The distribution of stripe rust (*Puccinia glumarum*) in Alberta in 1928.

growth made in 1928. As measurements were not taken in 1927 a definite statement on this point cannot be made, nor is it possible to state where the inoculum came from, or when the infection occurred. However, in view of the fact that during April and May, at Claresholm, weather conditions were very dry, it is most likely that the rust on the third leaf is merely a further development of the 1927 infection. One must admit, however, that there is a chance that the infection on the third leaves developed early

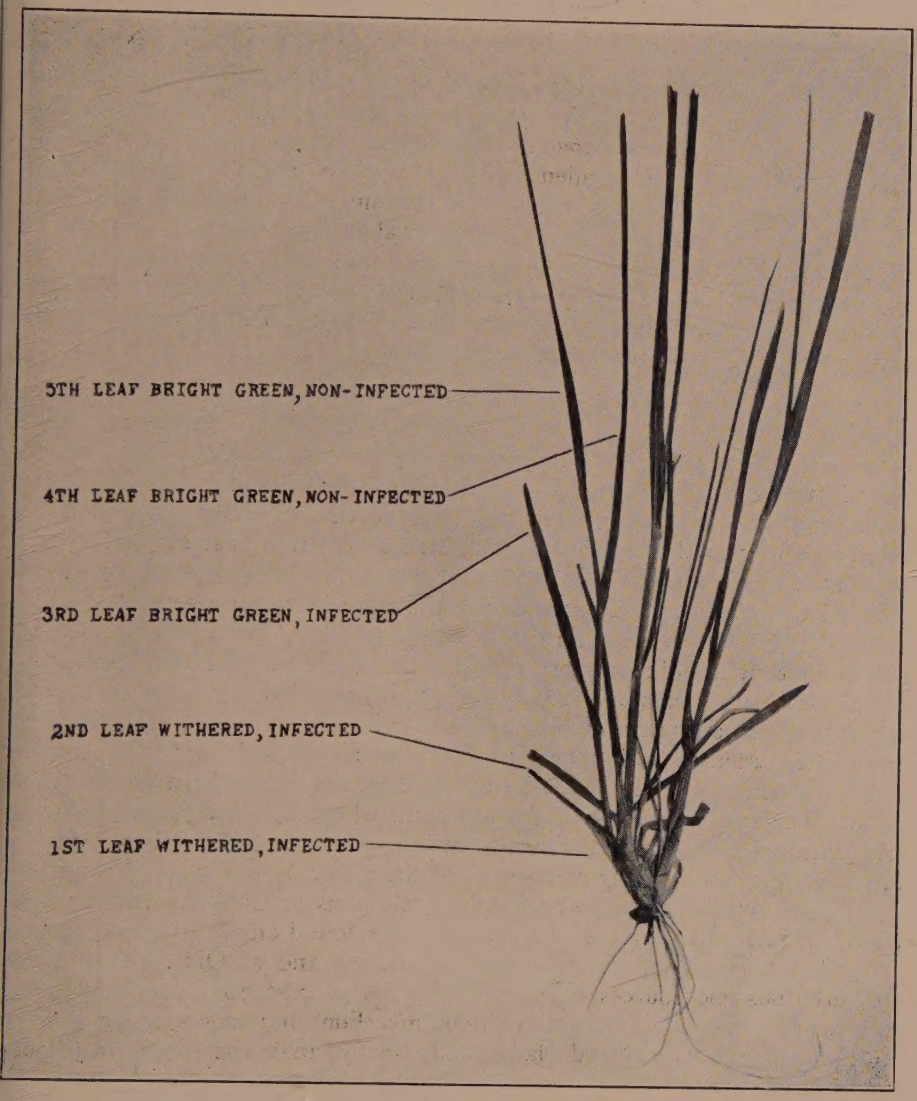
5TH LEAF BRIGHT GREEN, NON-INFECTED
4TH LEAF BRIGHT GREEN, NON-INFECTED
3RD LEAF BRIGHT GREEN, INFECTED
2ND LEAF WITHERED, INFECTED
1ST LEAF WITHERED, INFECTED

FIGURE 2—This wheat seedling was taken May 12, 1928, from a field of Kharkov M.C. 22, sown August 1927, at the School of Agriculture, Claresholm, Alberta. The first and second leaves were withered, and heavily infected with stripe rust. The third leaf was green, succulent and also heavily infected. The urediniospores on these leaves were found to be strongly viable.

in 1928, and came from the rust on adjacent leaves or neighboring plants, or from air-carried spores from outside regions. Considering there was no rainfall in this district during late April and early May, the first suggestion would seem more probable.

The rust on the old leaves of 1927 is a clear case of over-wintering of stripe rust. In Figure 2 the first and second leaves on the wheat plant belong to the 1927 growth, and are rusted by *P. glumarum*. The third leaf, which may belong to both 1927 and 1928, also has considerable stripe rust

on it. This is the first information obtained on over-wintering of stripe rus in Western Canada.

Winter wheat plants, perhaps, furnish better conditions for over-winterin of stripe rust and its development in the spring, than the other host of this rust in Western Canada. The winter wheat usually survives th winter fairly green and succulent, while wild barley and the Agropyrons di back to the sod rather completely in the autumn and, unless the spores an mycelium in the withered leaves remain viable long enough to infect th next season's growth, the inoculum must come from other sources. I this connection, Hungerford (*4*) states that he had found that the myceliu of stripe rust passes the dry summer months on the Pacific Coast as dor mant mycelium in the leaves of wild grasses.

On May 12, when stripe rust was found on wheat seedlings at Clares holm, an inspection was made at the Provincial School of Agriculture, Olds of a fairly large patch of *H. jubatum* which went into the winter heavil rusted, for evidence of stripe rust which had over-wintered. The old leave were dead, and the new growth was not yet visible. Later inspections o this patch of wild barley showed that traces of stripe rust did not appea until late in July. At this time stripe rust was already severe on the duplicat plots of Chagot wheat. In considering the behaviour of stripe rust at Olds and judging from the way stripe rust developed in Alberta during the sea son of 1928, it would seem very probable that there was a fairly liberal sup ply of air-borne spores distributed during July and later. It was mentione earlier that the stripe rust which had over-wintered on wheat at Claresholm and district, seemed to disappear by July, but reappeared later in the seaso at Claresholm and throughout the north, central and southern parts of A berta. The suggestion is that the inoculum which was being spread durin late July and early August, came from outside sources. The best evidenc for this is the case, already mentioned, of the rather severe and general infec tion of rust which developed on the duplicate plots of Chagot wheat at Olds when not more than a trace of stripe rust was found on wild barley growin in certain favoured places elsewhere in Alberta and at Olds. Thus ther are three possible sources of inoculum of stripe rust each season, namely rust which over-winters on green plants, mycelium and spores which surviv until late spring on withered plants and, finally, air-borne spores from out side regions.

Summary

In 1928 stripe rust, *Puccinia glumarum,* (Schm.) Erikss. & Henn., i recorded on *Hordeum jubatum* from more than 70 places in Alberta in fairl general distribution south of the North Saskatchewan river. Three collec tions of stripe rust on *H. jubatum* were made just north of the 55th paralle one in Alberta, and two in British Columbia.

Stripe rust was observed on the following hosts in Alberta in 1928 *Hordeum jubatum, H. vulgare, Triticum vulgare, T. durum, Agropyro smithii,* and *A. dasystachyum.*

A case of over-wintering of stripe rust in Alberta is reported.

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POTASH IN PASTURE FERTILITY

In opening a discussion on the economic use of potash fertilisers at the Braunton Agricultural Discussion Society, North Devon, on Monday evening, November 19th, Mr. G. A. Cowie emphasized, amongst other points, the supreme importance of balancing the amounts of nitrogen and potash for crops like mangolds, potatoes and sugar beet.

In the treatment of pasture, Mr. Cowie said that the two main effects of a potash application were closer grazing on the one hand, and a better growth of leguminous herbage on the other. The closer grazing, which generally followed a potash application, was a factor which had not been sufficiently well appreciated. In fact, this particular effect of potash in making rough herbage more palatable and causing it to be eaten down by stock, had been often "missed" in consequence of the too small dimensions of many experimental plots. This was more than a flavouring effect of any common salt which might be present in the potash fertilizer. It was a definite potash influence, causing a botanical or chemical modification of the herbage or producing a higher growth-rate.

A fact that should be strongly emphasized was the greater necessity for potash application as the treatment of pasture or grassland became more intensive by the application of nitrogenous fertilizers. The reason for this was that the more produce removed per acre from the land, the greater was the depletion of the potash supply in the soil. Young, short grass was extremely rich in potash, and it was necessary to replace the potash systematically if a deterioration of the pasture was to be avoided. There was no evidence that a dressing of lime released sufficient potash, even from clay soils, to influence the grass crop.

(From The Fertilizer, Feeding Stuffs and Farm Supplies Journal, London, England, December 12, 1928).

CHESHIRE CHEESE

PART I.

A PRELIMINARY STUDY OF THE BACTERIAL CONTENT

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The County Palatine of Chester has been justly famous for its cheese for many a day. Historically, but little Cheshire cheese was made outside the confines of the county itself—other than in North Shropshire, with Whitchurch as the centre. Within the last fifty years, however, the industry has spread to the bordering counties, and to-day the annual output of Cheshire cheese forms no inconsiderable part of the total weight of cheese manufactured throughout the whole of England.

In texture, flavour and quality a typical Cheshire cheese is distinct and characteristic. "A Cheshire cheese ready for consumption should be outwardly firm,....the texture open, soft and buttery, and not close, sticky, crumbly, greasy or leathery....the flavour should be full and nutty" says the Ministry of Agriculture (*1*). "Just sufficiently open in texture to stick to the knife, rich and mellow, and nutty in flavour" summarizes the judgment of other competent authorities.

Notwithstanding the establishing of factories, particularly during the last decade, Cheshire cheese is still, in the main, made on the farms. Through the generations have developed methods and procedures which, in some cases, constitute almost perfect art. And, in a measure, the making of Cheshire cheese is an art to-day rather than a scientific process based on and governed by the findings of research. In the actual making of the cheese the procedures have absorbed much that has come from studies on other cheeses. But, as far as I know, with the one exception of Smetham's work in 1892 (*2*), no researches have been published either on the fermentation changes taking place during the process of manufacture, or on the chemical and bacteriological sequences which constitute the ripening. Much has been published or written on that which stands for good practice; and continually, from the time of Henry Holland in 1808 (*3*) to that of W. H. Hobson in 1912 (*4*) recurs the plea for greater uniformity in the quality of the finished product. Holland (1808) (*3*), conducting a survey of Cheshire for the English Board of Agriculture, expresses the wish "that a cheese farm of experiment might be established in this county, under the patronage of the Board of Agriculture, and under the management of a person well skilled in chemistry, that something like scientific principles might be discovered, on which to conduct the process". Flint (1858), Joseph Aston, of Tarporley (1877) in particular, and James Long (no date) have much to say on the practice of Cheshire cheese-making and on the industry.

A distinct contribution was the paper given at the Cheshire Dairy Institute in 1882 by Alfred Smetham (*2*). A well-known chemist of his day, Smetham observes ".....an accumulated experience is a valuable inheritance.

†Professor of Dairying.

and it is largely to this fact that Cheshire farmers have for so long been able to take a foremost part among the cheese-makers of the world". He proceeds to suggest that the time has come to systematize this accumulated experience by conducting such experiments as would appear to be desirable and called for. He discusses the ferments which produce lactic acid, applies the knowledge then held of the characteristics of these ferments to the practical operations of the dairy and, in passing, suggests that 'sour curd' be added to the milk at the time of 'setting' as an alternative to the practice of developing the necessary acidity by keeping up the temperature of the evening's milk. Apparently investigations were begun at the instance of the Cheshire Chamber of Agriculture with the assistance of the Government of the day; for a meeting of the Chamber was held in April, 1892, to receive a report on the research made into Cheshire cheese-making at the Worleston Dairy Institute. In the same year a paper on cheese-making by Joseph Rigby (5) included the following:—"Recent investigations made at the Cheshire County Dairy Institute by Mr. A. Smetham, F.C.S., have shown the necessity of the proper ripening of the milk.....and of the production of acidity at such times that the operator can have it under control".....“Also that the rate at which the ripening of a cheese proceeds depends greatly upon the amount of ripeness present in the milk at the time of rennetting, and consequently on the rate at which acidity is produced in the curd"....“It was further found that the action of the ferment which produces acidity is not entirely checked by the salting of the curd, but.....continues while the cheese is under pressure, and during the ripening of the cheese.....". The complete text of Smetham's paper is interesting and informative in the extreme, and shows unusual insight. Later in the same year the Cheshire Chamber agreed to the offer of Mr. Henry Willis to demonstrate how cheese could be made without discoloration—a trouble by which many makers of 'coloured cheese' were beset. The demonstrations took place, and to some extent were beneficial, but for some reason or other no detailed report was ever published. Furthermore, the research work on Cheshire cheese appears to have stopped; and since 1892 no systematic work on the chemistry and bacteriology of the making or the ripening of Cheshire cheese has been published.

In 1892, John Benson (6) writes ".....no exact data can be readily considered to represent the Cheshire method since it varies considerably with different makers and according to which one of the three types of cheese it is intended to produce" .. "Throughout the Cheshire systems the endeavour is to develop more or less acidity after the curd is hooped."

Further papers dealing with the practice of Cheshire cheese-making were published by Miss J. Forster (no date), Mrs. M. Blackshaw (1909), Richard Mullock (1910) and W. H. Hobson (1912). Devoting himself to the Practice of Cheshire Cheese-making, Mr. Hobson (4) gives in detail the system of cheese-making practiced by his wife and himself. Unusual interest was taken in his paper because of the fame that had attached itself to the cheese manufactured in his dairy. In Hobson's description is to be seen a quite definite departure from the 'three systems', the applying of which for over forty years had been so significant of the practice on the

part of many makers. Says he "... we vary our system at Gonsley according to the time and season of the year, but they are variations of a minor nature and not in principle. The system in principle remains the same...." As to the length of time required for ripening, he observes "The cheese we make are usually ready for consumption in two months time, while they will keep for six and even twelve months". The system of the Hobsons, representative, on the whole, of that employed by the makers of the best Cheshire cheese, has a particular interest in this place. It was a cheese from Mr. Hobson's dairy on which a study of the bacterioligy of Cheshire cheese was begun in the laboratories of the University of British Columbia.

Contemplating on the possible explanations of the ripening of Cheshire cheese was an intriguing pastime for a number of years, and my interest was not lessened by reason of the fact that it was the Cheshire cheese from which Todd and Sadler (*7*) had evolved the Kingston cheese. As the work on Kingston cheese progressed in these laboratories it became increasingly necessary for us to know something of the chemistry and bacteriology of the cheese out of which it was developed. The best precedents suggested that the obvious thing to do, at the beginning, was to enquire into the bacterial flora of a ripe and characteristic cheese. The importance of getting material the typical characteristics of which could not be questioned suggested itself. The Dean of my Faculty (Professor F. M. Clement) authorized the importing of a cheese from the then most famous dairy in England engaged in the production of cheese of this type. By means of generous coöperation on the part of the Canadian Pacific Railway, through Mr. W. M. Hastie of the company's offices in Vancouver, we got a cheese consigned from Liverpool to Vancouver under almost perfect control throughout the entire journey. The cheese had been made by Mr. and Mrs. W. H. Hobson (*4*) and was part of an exhibit that had earned great distinction at a recent cheese show in England. Arriving in Vancouver early in 1925, the cheese was put in cold storage, and in March, 1925, the work was begun. At that time the cheese was about 9 months old.

The Bacteriological Examinations

Media Employed: (at this stage or later)

Bacillac Dehydrated Milk Agar.....Dry Milk Co., New York.
Peptonized Milk Agar.....Difco Dessicated. (*8*)
Whey Agar.
Nutrient Agar.
Purple-glucose-agar, nutrient agar to which 1% glucose was added, with brom-cresol-purple as indicator.
Nutrient gelatin.
Milk.....freshly separated milk, steamed in flowing steam for three successive days.
Litmus Milk.....prepared as above after adding the requisite amount of Azolitmin.
Casein-digest-agar after Orla-Jensen. (*9*)

Plate Counts:

Observing the necessary precautions a large block of the cheese was cut away. Working outwards from the centre thus exposed, 'bores' were

taken as samples. These were placed in petri dishes, and the material to be used for examination included pieces of cheese from different parts of the various 'bores'. In this manner a fairly representative sample was obtained. Using appropriate dilutions, employing bacillac agar and glucose agar as the media, and following, in the main, the methods of Harrison (*10*, *11*), plates were made to determine the total count. Triplicate sets of the bacillac agar plates and the glucose agar plates were incubated at 22°C. for 5½ days. Other sets of plates were put at 40°C. for several days. The counts appear below:

Bacillac Agar 22°C	Purple Glucose Agar 22°C
15,600,000 cols. per gram cheese	9,200,000 cols. per gram cheese

Bacillac Agar 40°C

3,500,000 cols. per gram cheese.

All the colonies, twenty in number, on one of the bacillac agar (22°C) plates were transferred to whey agar and kept for study. From other glucose agar or bacillac agar plates some forty cultures were retained for study.

Mass Inoculations in Milk:

Pieces of cheese were dropped into tubes of sterile milk and the whole incubated at 22°C and at 40°C respectively. The mass inoculations incubated at 22°C for three days showed good clots, typical of the clot produced by true lactic acid organisms when in pure culture. The mass inoculations incubated at 40°C, and later at 37°C showed good clots at first with in some cases a certain amount of digestion and a few gas holes after further incubation. Twenty-eight cultures were isolated from plates made of these mass inoculations.

Direct Contact or Impression Slides:

At the time of the examination, preparations were made from various parts of the cheese, and were treated and stained in the manner already described (*12*). Further reference to these slides is to be made when discussing the organisms present, and the photo-micrographs.

Histological Sections:

Sections were prepared from representative portions of the cheese, following the methods of Harrison (*13*):—those employed by me in the work on Kingston cheese (*12*). Although these sections were embedded three years ago, and are filed in the laboratory, a complete examination of the preparations has not been made as yet.

Bacteriological Examinations Made One Year Later

After the examinations in March, 1925, had been made, the cheese, paraffined where cut surfaces were exposed, was returned at once to cool storage (about 45° F.). In March, 1926, exactly one year later, a second examination was made. It is to be observed that at this time the cheese was about 21 months old. The procedures and methods employed before were duplicated, except that peptonized milk agar instead of bacillac agar was used for the plates.

The total count, after 5½ days incubation at 21°C was 93,400 colonies per gram cheese. Compared with the counts already given, one sees a

reduction from 15,600,000 to 93,400 colonies per gram cheese after one year in storage at 45°F. From the plates colonies were picked off and held for study. A few of these strains were kept in stock in agar stabs for nearly two years. Then, in a moment of forgetfulness, I threw them out. For this reason, little can be said on the organisms recovered from the cheese when it was 21 months old; other than that—reviewing the old notes —all the cultures were Gram positive rods which, after several days in milk, produced a solid clot.

Pieces of cheese were dropped into sterile milk, and the mass cultures were incubated at 21°C, 37°C, and 40°C respectively. Action was slow in some cases, but within 14 days all the milk cultures had clotted. The clots were solid, and typical of those produced by lactic acid organisms. Preparations were made, stained by Gram and examined. Usually Gram positive rods were found, some thin and some quite stout; in certain of the mass cultures that had been at the higher temperatures large cocci occurring singly, as twos and even as chains were observed, in addition to the rods.

Of the direct contact preparations taken at the time two must be referred to again when discussing the organisms present, and the photo-micrographs.

The Examinations Made March, 1925. (First Exam. Cheese 9 months old)

Morphology:

In April, 1925, the cultures isolated were examined microscopically, using Gram's stain. All had been at room temperature (about 21°C.) and for the length of time specified below.

After 20 days on whey agar, eighteen of the twenty cultures which formed the entire flora of one plate—the other two had died— were found to be *Rods,* usually well stained. Fourteen of the strains were stout rods with rounded ends; and in size the majority of the cells in each culture were 1.6 to 2.5 x 0.8 microns. Certain variations were to be observed, of course, and there would be cells as long as 4, 5, 6 and 11 microns. Some strains showed chains, but this was not a characteristic formation. In many cases there appeared to be a constriction at the middle of the cell. The remaining four of this group of cultures were smaller cells, many being 1.6 x 1.5 microns in size.

Of twenty-three other cuultures picked from quantitative plates, and grown on whey agar for several days at 21°C, all were *Rods* and well stained. In seventeen of the twenty-three cultures the cells were usually stout with rounded ends, measuring on the average 1.6 x 0.8 microns. Many cells might readily be mistaken for *cocci* in two's; but they are *rods* with the constriction noted already above. Of the remaining six cultures included here, one strain formed chains, some were more slender rods than the above, and one exhibited the curled forms shown in Orla-Jensen's photo-micrographs of certain of his *Streptobacteria* (*9*).

It is of no small interest to find that the forty-three strains referred to above, including as they do the whole of the colonies of at least one plate of the series, are all *Rods.*

Action on Milk:

In their action on litmus milk, some variations were noted. Incubations were usually at 37°C. While some strains clotted very definitely in 2 days, many required 14 days, and some failed to clot the milk. A few strains bleached the litmus. Of the forty-three cultures some 35 produced a clot and the majority of the remainder produced acidity in milk.

It has been said earlier that twenty-eight cultures were isolated from plates made from the mass inoculations of cheese in milk. The records on the morphology of these strains are not complete. A few strains appeared as ovoid cocci from 0.5 to 0.8 microns in diameter; some were rods 1.6 to 2.5 x 0.5 microns, and included the curled forms mentioned immediately above; one strain, appearing as stout rods with rounded ends, showed also many curled cells, but the usual cell was 1.6 to 3.3 x 0.8 microns in size. All the cultures recovered from certain of these plates produced a solid clot in milk.

Direct Contact Slides:

a. Preparation from the heart of the cheese; many cells 5 x 1.3 microns, appearing at times in two's; many 6.6 x 0.8 to 1.2 microns; many 3.3 microns long; some 8.0 x 0.8 microns; some 13 x 0.8 microns; a few short stumpy rods 1.6 x 1.3 microns and 2 x 0.8 microns. For one field of this slide see Fig. 1 on the Plates.
b. Preparation from cheese nearer the surface; some cells almost coccoid, in two's and three's and many short stumpy rods; some 4 x 1.6 microns.
c. Preparation from a part of the cheese showing 'bleaching': principally stumpy rods; 1.6 x 1.3 microns, 2.0 x 0.8 microns, 2.5 to 3.3 x 1.3 microns; others were 2.5 x 0.5 to 0.8 microns; also some curled forms observed. One field shown in Fig. 2 on Plates.
d. Another preparation near centre of cheese; usually stout rods, 1.6 to 2.0 x 0.8 microns; some 3.3 x 0.5 microns. See Fig. 3 on Plates.

The Examinations Made March 1926. (Cheese 21 months old.)

a. Rods 3.3, 4.5, 5.0 and 7.5 microns long by 1.6 broad; some but little longer than broad, and in two's; some 8.3 microns long; the majority 2.5 to 3.3 microns long. See Figs. 4 and 5 on Plates.
b. Rods majority stout cells, 2.0 x 1.0 microns and 2.5 x 0.8 microns; some cells 11.6 x 0.8 microns; some 6.6 x 1.6 microns; some cells with flat ends, in two's.

WORK RESUMED DECEMBER, 1927.

In December, 1927, inoculations were made direct into litmus milk from the nutrient agar stabs (Freudenreich culture tubes) in which the strains had remained without transfer for a year. While some strains could not be revived, many proved still to be active and a number of them produced a clot in milk within 14 days. At this stage many cultures were eliminated. Those retained include 13 of the 20 which constituted the entire flora of one plate when the examinations were first made in 1925. Even though 7 strains had died, the remaining 13 may be taken as being fairly representative of the cheese flora. In addition, 6 strains representing others of the original 1925 plates are retained. I now have in stock 19 cultures which were isolated over three years ago, and on which more detailed studies have been or are being conducted. The 19 strains are all in stock in Orla-

Jensen's casein-digest-agar (*9*) stabs using Freudenreich culture flasks. For the observations which are to follow below, the strains were streaked on peptonized milk agar slopes, were incubated for 48 hours at 30°C. and examined microscopically using Gram's stain. After the preparations had been made, litmus milks were inoculated from the same streaks, then 5 days old, and were incubated at 30°C.

Microscopic Examination of Cultures on Peptonized Milk Agar Streaks

After 48 Hours at 30°C.

The first 13 cultures represent two-thirds of the entire flora of a plate; and as there are certain variations shown on examination I give the morphology for each culture:

Culture CC_{69} Rods in chains; individual cells 3.0 to 3.3 x 0.3 to 0.6 microns; many chains 16.6, 20, 25 and 33 microns long. See Fig. 6 on Plates.

Culture CC_{70} Stumpy rods, some in chains, many in two's and singles; majority of rods 1.6 to 1.9 x 0.8 microns; some cells 2.0 to 2.5 x 0.8 microns.

Culture CC_{71} Stout rods often in twos and short chains; majority 1.6 to 2.5 x 0.8 microns. See Fig. 7 on Plates and in Part II.

Culture CC_{73} The majority stout rods 2.5 x 0.8 microns; many 2.0 x 0.5 to 0.6 microns; some 1.6 x 0.9 microns; occasional cells 9 microns long; some two-cell chains.

Culture CC_{76} Stout rods with rounded ends often in two's, the two cells 4.5 microns long; many cells 2.5 and 5 microns often in two's.

Culture CC_{77} Stout rods with rounded ends often in two's, the two cells 4.5 microns long; many cells 2.5 and 5 microns long and many 0.8 to 1 microns broad.

Culture CC_{78} More slender rods and in chains: size of cells 2.5 x 0.4 microns; some cells 6.6 microns long; some cells curled as seen on No. 33, Plate 39 in Orla-Jensen's monograph (*9*) and Table in Part II.

Culture CC_{82} Many fat cells 2.5 x 1.6 microns; others stout with rounded ends 2.5 x 0.8 microns; some 2.7 x 0.7 microns; some 5.8 microns long; some as chains of four cells, each 2.8 x 0.7 microns.

Culture CC_{83} Stout rods in short and long irregular chains; majority 1.6 to 2.5 x 0.5 to 0.8 microns; many of the shorter cells often in two's; occasional oblong forms 8.3 microns long.

Culture CC_{85} Majority 1.6 x 0.4 microns, sometimes in chains of two or three cells; characteristic depression in middle of cell, (this one culture examined at 5 days old.)

Culture CC_{86} Long chains, threadlike and often twisted; many 10 x 0.4 to 0.5 microns. See Fig. 8 on Plates, and Table in Part II.

Culture CC_{87} Stout rods, rounded ends: 2.5 x 0.8 microns some cells 3.3 x 1.6 microns; some 3.3 x 1.6 microns with constriction at middle of cell; occasional cells with broad base coming to a point and 2 microns long; short chains with individual cells almost as broad as long.

Culture CC_{88} Rods 2.5 x 0.5 microns, often in two's and chains; some cells 3.3 x 0.4 to 0.5 microns; many curled cells as defined for Culture CC_{78}; Note: The examination of this same culture in 1925 showed the prevalence of the curled forms; evidently a constant characteristic. See Fig. 9 on Plates.

. . . . . .

Culture $_{54}$ Stout rods; cells in doubles, each single cell 1.6 microns long; some pointed rather than rounded ends observed; many cells 2 x 0.8 microns some chains 15 x 0.5 to 0.8 microns. See Fig. 10 on Plates, and Table in Part II.

Culture $_{53}$ Rods, rounded ends: 2.5 to 3 x 0.5 microns; some 4 x 1.2 microns; some very stout almost as broad as long, many 2.5 x 1.2 microns; chains 5 to 6.6 microns long and many in two's; a few cells 33 microns long. See Fig. 11 on Plates.

Culture $_{52}$ Stout rods rounded ends, often in two's, 2.0 to 2.5 x 0.8 microns; some short chains; some cells 4 microns and some cells 13 microns long.

Culture CC_{50} Stout rods, rounded ends, 1.6 to 2.5 x 0.5 to 0.8 microns; many in two's with slightly tapered ends 1.6 to 2.0 microns long the single cell; some cells 4 and some 9 microns long; occasional cells 50 x 0.8 microns.

Culture CC_{46} Stout rods with rounded ends, 1.2 x 0.8 microns; some but little longer than broad; some 2.5 x 0.8 microns. See Fig. 12 on Plates.

Culture CC_2 Rods as chains, individual cells 2.0 to 2.5 x 0.4 to 0.5 microns; some cells extremely long and curved, 66.4 x 0.7 microns; many curled as defined for CC_{78}. See Fig. 13 on Plates, and Table in Part II.

Action in Litmus Milk of the Foregoing 19 Cultures (Incubation at 30°C.)

Cultures CC_{88}, CC_{78}, CC_{77}, CC_{69}, CC_2 produced a firm clot with bleaching of the litmus within 3 days; culture CC_{53} clotted within 5 days with bleaching, and at this time cultures CC_{86}, CC_{82}, CC_{76}, CC_{52}, CC_{50}, had begun to clot at the bottom of the tube, with bleaching of the litmus. Later, these cultures, and cultures CC_{83}, CC_{73}, CC_{71}, CC_{70}, CC_{54}, produced complete clotting; but in 21 days cultures CC_{87}, CC_{85}, and CC_{46} had clotted the lower layers only of the milk.

Summary of Part I.

A preliminary study of the bacterial content of Cheshire cheese was begun in 1925.

The work has been done on an imported cheese, typical in its characteristics, and nine months old on the first examination.

The total count was 15,600,000 colonies of bacteria per gram cheese.

Some sixty cultures were isolated from the quantitative plates, and observations on the morphology of the organisms and of their action in milk are reported.

All the cultures isolated from the quantitative plates proved to be *rod-forms,* and many are active in milk.

A further examination was made in 1926 when the cheese was 21 months old. All colonies isolated from the quantitative plates proved to be rod-forms, many of which were active in milk. The total count was 93,400 colonies per gram cheese.

Comparing the two total counts it is seen that the count declined from 15.600,000 to 93,400 colonies per gram cheese after one year in cool storage.

Direct contact or impression slides were prepared from the cheese at each examination, were studied, and are shown pictorially on the Plates.

The most significant feature of the preliminary study is the finding that all bacterial strains isolated from this typical Cheshire cheese, by the quantitative method, are *Rod-forms.*

Explanatory Note

As the work progressed, the necessity of employing methods of study with which I was not then familiar became imperative. Transferred to Europe, with certain of the strains isolated, I became associated with Professor Orla-Jensen in making those critical determinations on which the systematic classification of the Lactic Acid Bacteria so largely depends. The work done on the organisms specified is reported upon in Part II.

Part II.

THE CLASSIFICATION OF CERTAIN ORGANISMS ISOLATED

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A particular interest in the cheese bacteria, and a desire to study them further, had led the senior author to engage in a comprehensive and systematic study of the lactic acid bacteria (*9*). It is but natural, therefore, that in seeking an explanation of the ripening and the characteristic flavour of a cheese such as the Chesire, a study of the organisms isolated should offer attractions.

In the introduction to the report on the study referred to above, the difficulty of understanding why various kinds of hard-pressed cheese, apparently containing the same microflora, should each have the taste and smell characteristic of the type, is commented upon. "There can hardly be any doubt", it is observed, "that these sorts of cheese in reality contain different species of bacteria, only we are unable to distinguish them by the methods hitherto employed. The object of the present work is primarily to meet this want by describing the useful bacteria of the dairy industry so thoroughly that it may be possible in the future to identify the strains encountered"(*9*). The protracted study of the lactic acid bacteria emphasized the importance of bringing the various strains together only on the sum of their characteristics. This became the guiding principle. It is difficult to conceive that any of the studies defined can be dispensed with, for "Only by taking note of all qualities can we arrive at a natural bacterial system" (*9*). A concluding paragraph in the work on The Lactic Acid Bacteria (*9*) reads as follows:- "It will be seen then, that many different species of lactic acid bacteria contribute to the ripening of the cheese, but there is hardly any doubt that cheese—as has been proved in the case of the Emmenthal cheese—only obtains the proper character when certain definite species are predominant".

What species predominate in a typical Cheshire cheese? In the absence of any available data, an inquiry into the prevailing species of bacteria in a mature cheese so characteristic as is the Cheshire, is not without its fascination. In Part 1 of this paper it is shown that, by the quantitative method, all bacterial strains isolated from the Cheshire cheese under examination are found to be *rod-forms*. An attempt to define the species into which some few of these rods should be placed, is the object of this immediate study. The small number of cultures we are considering here were chosen at random from the strains isolated in the manner described in Part 1: the idea being that the work reported here might serve as a guide in the study proceeding in another place.

Methods and Media

The methods followed in his study were those employed in the classification by one of us (O.-J.) of the lactic acid bacteria, and for a detailed description the Monograph on The Lactic Acid Bacteria (*9*) is to be consulted. Likewise with respect to the media used. Consulting the reference will reveal that the more important considerations are held to be a study of the morphology, the quantitative determination of acid production in eighteen carbohydrates and in milk, the degree to which the strain can form soluble nitrogen and amino nitrogen after incubation for six weeks in chalk milk and the type of lactic acid—dextro, laevo or inactive—that is formed. As to media, the importance of the nitrogen source is emphasized, and the suitability therefore of casein digest is to be observed.

The Determinations

The results of the determinations made are to be found in the accompanying Table. In considering the sum of the characteristics of the strains, the results in the Table are to be supplemented by reference to the morphology studies of Part 1, and the Plates.

At the time the determinations recorded on the Table were done, every culture was at least 18 months old, and had been held in stock on nutrient agar for the greater part of that time.

Classification

Culture CC_{86} It is to be seen from the Table that all the sugar in the chalk milk had been fermented, and that a high volatile acid figure, for a culture of the age specified, was obtained. The morphology—see Part 1 and Fig. 8 on the Plates—and the characteristics according to the Table suggest that the strain be placed among the *Streptobacteria;* while in particular the rotary power exhibited by the organism, its vigour in certain of the sugars, and its casein-splitting properties indicate that it is a strain of *Streptobacterium casei* (*9*). The production of such a small amount of acid in lactose is the most striking feature of the sugar fermentation results. Usually,*Sbm. casei* ferments lactose more strongly then it does the other disaccharides. Yet strains which almost if not entirely have lost the power to ferment lactose have been encountered before. This is more especially true of numbers 5 and 23 of the *Sbm. casei* group reported upon in The Lactic Acid Bacteria (*9*); each of these strains having been isolated from dairy cheese three and two months old respectively. Numbers 5 and 23 give rather more Sol.

No.	Isolated from	Lactic Acid Rotary Power	Nitrogen Source	% Sugar Fermented	Volatile Acid Figure	Glycerine	Xylose	Arabinose	Rhamnose	Sorbite	Mannite	Laevulose	Glucose	Mannose	Galactose	Saccharose	Maltose	Lactose	Raffinose	Inulin	Dextrin	Starch	Salicin	Milk: Time of Curdling (Days)	Milk: Amount of Acid	Milk: % of Total N: Amino N	Milk: % of Total N: Sol N
CC_{86}	Cheshire Cheese	D	Casein-digest	All	57.75	0.5	0.2	0.7	0.5	3.8	3.6	8.3	9.7	10.1	8.0	5.0	3.4		0.2	0	0.2	0	3.6	5	10.8	9.47	12.06
CC_{71}	"	i	"	All	40.38																			5+		2.75	3.08
CC_{54}	"	i	"	3.56	38.63	0.7	0.7	4.6	0	0.2	3.8	8.6	8.6	9.3	5.0	0.7	9.1	7.7	0.2	0	0.5	0	7.2	5+	3.2	1.25	0.0
CC_{72}	"	D	"	3.59	17.60	0.9	0.2	0	0	0	2.9	6.8	5.6	7.0	2.9	0.5	6.8	6.0	0.2	1.1	0.2	0	5.0	5+	1.4	0.66	0.26
CC_{2}	"	D	"	Trace left	26.2	0.8	0.7	0.5	0.2	0.3	3.4	10.1	10.1	10.1	8.3	11.0	10.6	8.3	5.0	14.0	0.7	0	6.1	3	12.4	0.50	2.20
CC_{78}	"		"			0.7	0.2	0.7	0.5	4.3	4.3	9.5	9.9	9.7	8.4	3.2	3.6	9.3	0.5	0.2	0.5	0	4.1		12.4		
CC_{49}	"		"			1.0	0.5	0.2		2.8	3.3	8.9	8.0	10.7	5.9	1.2	8.9	6.0	8.6	0.6	1.7	0.5	6.0		2.7		

Sugars are titrated against ¼ N. NaOH with phenol phthalein as indicator and the results are recorded as grams lactic acid per mille.

N. than Amino N., whereas Culture CC_{86} gives more Amino N. than Sol. N. —all in per cent of the Total N. Numbers 5 and 23 have no action on sorbite. Culture CC_{86} is quite vigorous in sorbite; and in this respect relates itself to numbers 28 to 34 of the *Sbm. casei* strains previously studied (*9*). Each of these organisms, however, produces much acidity from lactose. The fermentation of sorbite (and rhamnose) is more significant of *Sbm. plantarum* than of *Sbm. casei;* but activity in sorbite is accompanied by the power to ferment inulin in the more specific casein-splitting strains of *Sbm. plantarum* (*9*). This combination is not to be found when considering the results of the determinations on Culture CC_{86}. Consequently on the morphology—Part 1 and Fig. 8 on the Plates—and on the sum of the characteristics as defined on the Table, Culture CC_{86} is to be regarded as a *Streptobacterium casei* strain (*9*); a strain which, in artificial media, is weak in the fermenting of lactose.

Culture CC_{54} The characteristics as a whole of this strain place it in the genus Streptobacterium. The morphology—Part 1 and Fig. 10 on the Plates—the production of inactive lactic acid, the absence of casein-splitting ability, the definite fermentation of arabinose and the slow action in milk determine the placing of Culture CC_{54} within the species *Streptobacterium plantarum* (*9*). Considering this species on a broad basis, the dominant characters to be sought are significant and well defined. At the same time there are certain variations to be found when comparing a large number of strains in detail. Uusually, as has been shown, (*9*) *Sbm. plantarum* prefers maltose and saccharose to lactose when casein-digest is the source of nitrogen. Culture CC_{54} appears to be more active in maltose then in lactose, but is unable to ferment saccharose. In its relation to the fermentation of arabinose this strain displays the distinctive ability observed in several instances when the systematic study of The Lactic Acid Bacteria (*9*) was in progress. In view of the foregoing observations it is of interest to find that Culture CC_{54} alligns itself so specifically with Number 5 –a strain isolated from a dairy cheese 4 weeks old—of the organisms included by the senior worker in his species *Streptobacterium plantarum* (*9*). And, on the sum of the characteristics, Culture CC_{54} is classified as a strain of *Streptobacterium plantarum* (*9*).

Culture CC_{72} Morphologically, when first isolated three years ago, this organism appeared as rods 2.5 to 3.3 x 0.8 microns, with constrictions shown at the middle of some of the cells. The main characteristics of the organism would appear to guide it into the genus Streptobacterium. Although dextro-lactic acid is formed, the inability of the culture to split casein, the weak action in milk, and its activity in the sugars preclude our placing it as *Sbm. casei.* Some strains of *Sbm. plantarum* can form dextro-lactic acid; but the majority of these according to previous studies (*9*) are strong fermenters of saccharose, or of inulin, or of both. Number 28 of the *Sbm. plantarum* strains (*9*) is weak in both saccharose and inulin, as is seen to be the case with Culture CC_{72}; but Number 28 produces high acidity in milk, a quality lacking in the culture we are discussing. Considering the results of the determinations recorded on the Table as a whole, it is to be seen that this strain is weak in many important respects. For the present, therefore, on

the sum of its characteristics, we place Culture 72 as a weak strain of *Streptobacterium plantarum* (*9*).

Culture CC_2 The morphology—see Part 1 and Fig. 13 on Plates—appears to be on the border line of the two species of the genus Streptobacterium (*9*); but the determinations according to the particulars on the Table point more particularly in the direction of *Sbm. plantarum*. Although producing dextro-lactic acid, the strain is weak in its ability to split casein, more Amino N. than Sol. N. being formed. Greater activity is shown in both saccharose and maltose than in lactose; raffinose is fermented quite definitely, and very pronounced activity is observed in inulin. These sugar reactions are found to be characteristic and typical of *Sbm. plantarum* as shown in the systematic study of The Lactic Bacteria (*9*). In those studies it was seen that some of the inulin fermenting dextro-lactic acid producing strains had the power to split casein very definitely; to wit, numbers 20 and 21. One or two other strains fermenting inulin vigorously and giving dextro-lactic acid had little effect on the casein. In the former studies it was found that usually the dextro forms were unable to ferment raffinose. Culture CC_2 is active in raffinose. Of the 44 strains previously included within the species *Sbm. plantarum* (*9*)„ Number 7 is one to which, possibly, Culture CC_2 attaches itself; but even here the two strains vary in their action on sorbite and raffinose, and Culture CC_2 is much stronger in its action on milk than is Number 7. The variations found here and there notwithstanding, it will be seen that on the sum of its characteristics Culture CC_2 quite clearly finds its proper place as a *Streptobacterium plantarum* (*9*) strain.

In the absence of data on so many of the requisite determinations Cultures CC_{71}, CC_{78}, and CC_{49} are not to be considered at this time.

The number of strains to which a place in the Classification has been assigned is small. No conclusion is to be drawn as to the species of bacteria which predominate in a mature Cheshire cheese. If the work reported here be supplemented, however, by similar work on the 13 representative strains still in the laboratories of the University of British Columbia, some guidance in pursuing the study of the bacteriology of Cheshire cheese may be assured.

Mr. Sadler's Acknowledgments

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PLATES

The Bacteria of Cheshire Cheese. Gram's Stain used in all cases. Magnification throughout x 750.

For the photo-micrographs a Leitz machine with a Zeiss (K8.10x) compensating ocular and a Zeiss No. 90 (1.3) apochromatic oil immersion objective were used.

Plate I.

Figure 1. Direct contact slide; centre of cheese: cheese 9 months old.

Figure 2. Direct contact slide: part of cheese showing bleaching; cheese 9 months old.

Figure 3. Direct contact slide: near centre of cheese; cheese 9 months old.

Figure 4. Direct contact slide: cheese 21 months old.

Plate II.

Figure 5. Direct contact slide: cheese 21 months old.

Figure 6. Culture CC_{69}: 48 hours 30°C. on peptonized milk agar.

Figure 7. Culture CC_{71}: " " " " " "

Figure 8. Culture CC_{86}: " " " " " "

Plate III.

Figure 9. Culture CC_{88}: " " " " " "

Figure 10. Culture CC_{54}: " " " " " "

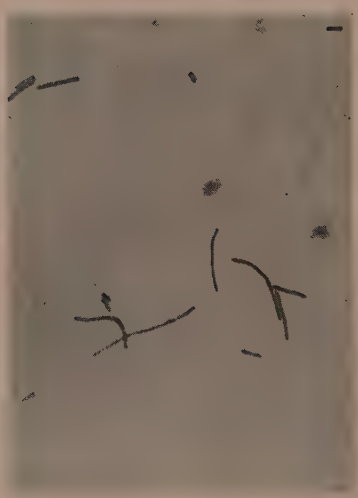
Figure 11. Culture CC_{53}: " " " " " "

Figure 12. Culture CC_{46}: " " " " " "

Figure 13. Culture CC_{2} : " " " " " "

Preparations by Wilfrid Sadler. Photo-micrographs by Percy Bentley.

PLATE I.



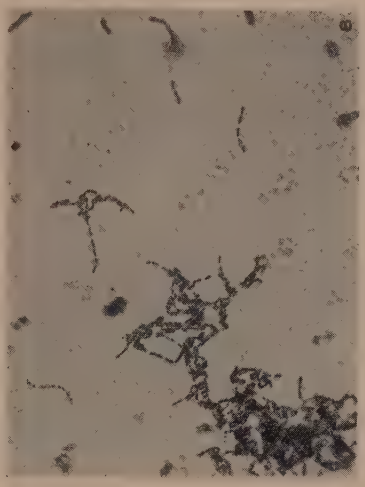
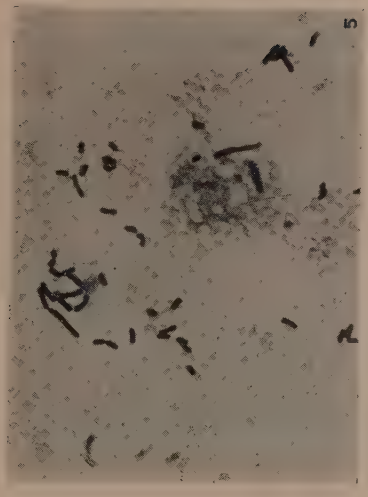


PLATE II.



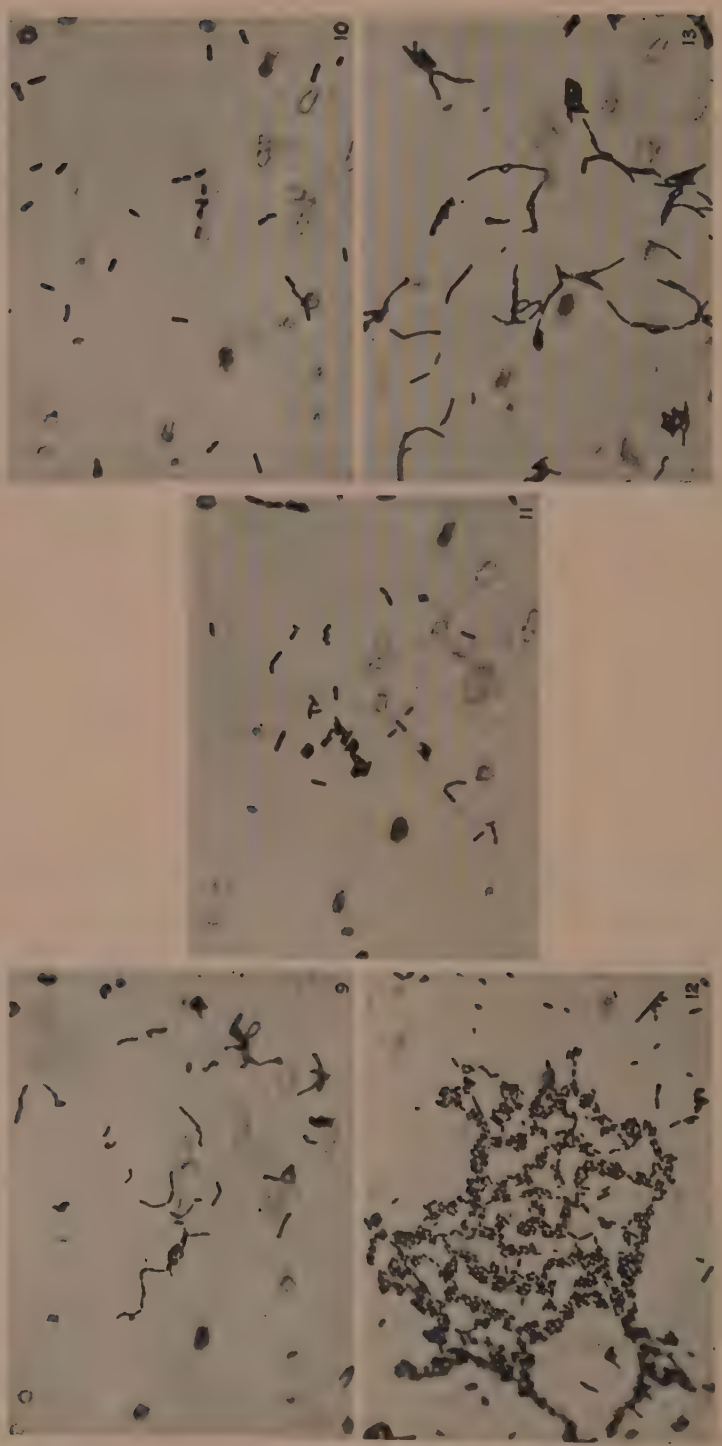


PLATE III.

THE USE OF A STEAM STERILIZER FOR DAIRY UTENSILS ON THE FARM

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University of British Columbia, Vancouver, B.C.

[Received for publication December 1, 1928]

Introduction

Many investigations by Stenhouse Williams and his associates (*1*) and those of Ayers, Cook and Clemmer (*2*) have shown the significance of sterile utensils in the production of high grade milk.

The Clean Milk Competitions in Great Britain (*3*) have shown the significance of the sterilization of utensils in the hands of the farmer. The report of the inspecting judge of the competitions has the following opening paragraph:

> "The herds that I have so far inspected are chiefly herds which were entered last year and it is very noticeable that great improvements have taken place since my last visit. At this period of the last competition it was only in exceptional cases that a steamer was seen but now it is rare to find a competitor without one of some sort".

An increased demand by the farmer for a suitable steam sterilizer has led to the designing of several cheap low pressure steamers. The simplest is the one by Ayers and Taylor (*4*) which has been tested as to its efficiency both in the United States and in England. More elaborate steam sterilizers are being made by Barford & Perkins Ltd., of Peterborough, England, and these are now being used on many farms. Intermediate between these two steam sterilizers is the one designed for farms in British Columbia, by one of us (Golding) with the assistance of the Department of Mechanical Engineering of the University of British Columbia.

In a recent publication (*5*) a description of the construction and methods of operation of the apparatus is given. Also (*5*) are included the results of the bacteriological test conducted to determine the efficiency of this steam sterilizer.

Herein we report experiments conducted to define what the farmer may accomplish in improving the quality of his milk by using this steam sterilizer on his own farm. On the farms included in the experiments no attempt was made to alter the existing conditions other than in the respect of steam sterilization of utensils.

Farms

The farmers approached were those in the Fraser Valley, who ship their milk to one or other of the milk depots in Vancouver. During the winter months no effort was made to find out the bacterial quality of the milk that had been shipped before the farmer was approached. Therefore, the five farms reported on may be described, in general, as representing the average. During the summer months some assistance was kindly offered by the Fraser Valley Milk Producers' Association, and among the six farmers approached were some who had had trouble with their milk. Therefore, these farmers may be considered in general as shipping milk of poorer quality than the average.

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The Farmer to Use Sterilizer

The procedure followed was to interview the farmer personally, obtain his coöperation and his promise to operate the sterilizer. The object of the experiment was explained with special reference to the fact that no changes in his previous methods other than the washing and steam sterilizing of the utensils were required. Two weeks were then allowed to elapse before the sterilizer was brought to the farm, during which time four samples of the milk were taken at the receiving depot in Vancouver. These four samples taken on different days, were examined bacteriologically so as to obtain a fair idea of the quality of the milk that was being produced under existing conditions. The steam sterilizer was then taken to the farm, set up, and one demonstration of its operation was given to the farmer.

Treatment for Utensils

The method recommended was to wash all the pails, strainers, cooler and any other small utensils in warm soda water, rinse in cold water and then steam for three minutes. The cans received from the milk depot, being already washed, were steamed for three minutes. All utensils were left to dry in the most suitable place available.

During the winter months the steam sterilizer was recommended to be used only once a day after the morning milking; the utensils used in the evening milking being washed in warm water. During the summer months the steam sterilizer was recommended to be used twice daily.

After the one demonstration the farmer was left to operate the steam sterilizer and no close account was kept as to how this work was done. Our apparent neglect in this case was intentional, as the experiment was to determine not what could be done with a steam sterilizer on the farm, but rather what results a farmer would obtain by using a steam sterilizer on his own farm.

Four samples of milk were taken at the milk depots in Vancouver during the two weeks the farmer was operating the steam sterilizer.

Considerable variation was found in the degree of coöperation of the different farmers approached to operate the machine. One farmer purchased a steam sterilizer to replace the one on loan from us. Another farmer used the machine only part of the time. By this, it should not be inferred that the coöperation on the part of the farmer was not all that could be expected There was no remuneration to the farmer for operating the steam sterilizer, and there was but one price for sweet milk of all bacteriological grades.

Methods Employed

Sampling the Milk. All samples of the farmer's milk were taken at the milk receiving depots in the city of Vancouver. By so doing, the true quality of the milk as delivered was recorded, but all the factors of efficiency of cooling, time of holding, and temperature in transit were included and may have influenced the quality of the milk. The method of sampling was to take a sterile aluminium tube (¼" diameter) sufficiently long to reach the bottom of the can and to add one tube of milk from each can delivered, into a sterile bottle. Thus a proportionate sample of milk was obtained of both morning and evening milk and, in some cases, as shown in Table 2, this included milk that was rejected as sour or of bad odor. The sample of milk

was at once put on ice in an insulated box and taken to the laboratory for examination. All iced samples of milk were examined less than four hours after they were taken.

Plate Count. The plate counts were made on Difco purple lactose agar using the necessary dilutions and incubating for 48 hours at 37°C. before counting. The plates were made in duplicate and the number of colonies of bacteria in the two plates of most suitable dilution was averaged and expressed as the number of bacteria per cc. of milk.

Direct Count. In the earlier part of the work direct counts were made according to Standard Methods of Milk Analysis (*6*). but owing to the large number of samples of low count milk this was discontinued.

Methylene Blue Test. The methylene blue test was made according to Standard Methods of Milk Analysis (*6*), using 1 cc. of solution of methylene blue in 10 cc. of milk and incubating at 37°C.

Coli Test. The method used for determining the coli is that described by Sadler (*7*). The results are expressed by + or — signs which refer to the presence or absence respectively in the dilutions stated. The — sign is only used where coli was not found in 1 cc. as not more than 1 cc. of milk was used in the determination.

Temperature. The temperature of the milk, due to weather conditions will vary from day to day; hence this additional and important factor must be considered. To record the temperature of the milk on arrival at the depot would have been a good index had not each farmer been delivering several cans of different quantities at different temperatures. Further, there were no means of determining the rise in temperature during the transit. Therefore, the temperature given in the tables is the average hourly temperature in Vancouver on the day the sample was taken (*8*).

Weights and Grades. The weights and grades of milk, sweet, bad odor or sour are those given by the man in charge of the weigh stand at the respective city milk plants and have been kindly furnished to us by the dairies concerned.

Expression of Results

The results obtained with the winter milk are given in Table 1; for the summer milk in Table 2. These tables give the actual figures obtained by the bacterial analysis of each sample of milk. No attempt is made to state whether or not the farmer was using the steam sterilizer according to direction, but it is well to note that in the case of farmer No. 6 it was known that the steam sterilizer was only in use part of the time. Table 3 is an attempt to grade the milk into four groups according to the bacterial content.

The Standards taken are from the Commission on Milk Standards (*9*), with the exception that the milk of below 100,000 bacteria per cc. is divided into two groups. The "Very Good" included milk showing below 30,000 bacteria per cc., the standard adopted for certified milk in Great Britain. It is fully recognized that there are a large number of other standards to choose from and, therefore, any standard selected would be more or less arbitrary. However, most standards would show the same general trend as the one selected.

TABLE 1. WINTER CONDITIONS

Two weeks before using the sterilizer.

Date Sampled 1928	Farmer's Number	Weight of Milk, lbs.	Grade	Air Temp. at Vancouver °F.	Plate Count 48 Hrs. at 37°C. Bacteria per cc.	Methylene Blue Test Hrs. to reduce	B. Coli
Jan. 21	1	192	Sweet	38	27,000	Over 5½	+ 1 cc.
" 26	1	234	"	41		" 5½	— 1 cc.
" 27	1	229	"	42		" 5½	— 1 cc.
Average				40.33	27,000		
Feb. 2	2	502	Sweet	46	130,000	Over 5½	— 1 cc.
" 3	2	606	"	45	210,000	" 5½	+ 1 cc.
" 9	2	606	"	41	240,000	" 5½	— 1 cc.
" 10	2	502	"	44	101,000	" 5½	+ 1 cc.
Average				44	170,250		
Feb. 15	3	100	Sweet	36	14,600	Over 5½	+ 1 cc.
" 16	3	204	"	36	18,100	" 5½	+ 1 cc.
" 22	3	102	"	36	11,400	" 5½	— 1 cc.
" 23	3	102	"	33	20,800	" 5½	— 1 cc.
Average				35.25	16,225		
Feb. 29	4	304	Sweet	39	96,000	Over 5½	+ 1 cc.
Mar. 2	4	390	"	39	58,000	Not Performed	+ 1 cc.
" 7	4	304	"	48	79,500	Over 5½	— 1 cc.
" 8	4	406	"	47	296,000	" 5½	+ 1 cc.
Average				43.25	132,375		
Mar. 14	5			40	36,000	Over 5½	+ .1
" 22	5			48	317,000	" 5½	+ 1
" 28	5			45	43,000	" 5½	+ 1
" 29	5			44	32,000	Not Performed	Not Performed
Average				44.25	107,000		

Two weeks during which the sterilizer was used.

Date Sampled 1928	Farmer's Number	Weight of Milk, lbs.	Grade	Air Temp. at Vancouver °F.	Plate Count 48 Hrs. at 37°C. Bacteria per cc.	Methylene Blue Test Hrs. to reduce	B. Coli *
Feb. 2	1	234	Sweet	46	22,800	Over 5½	— 1 cc.
" 3	1	236	"	45	9,150	" 5½	+ 1 cc.
" 9	1	212		41	5,450	" 5½	— 1 cc.
" 10	1	174	"	44	22,000	" 5½	+ 1 cc.
Average				44	14,850		
Feb. 15	2	510	Sweet	36	11,200	Over 5½	— 1 cc.
" 16	2	570	"	36	9,150	" 5½	— 1 cc.
" 22	2	504	"	36	18,000	" 5½	— 1 cc.
" 23	2	586	"	33	4,050	" 5½	— 1 cc.
Average				35.25	10,600		
Feb. 29	3	102	Sweet	39	5,350	Over 5½	— 1 cc.
Mar. 2	3	102	"	39	14,100	Not Performed	— 1 cc.
" 7	3	102	"	48	12,200	Over 5½	— 1 cc.
" 8	3	100	"	47	13,700	" 5½	— 1 cc.
Average				43.25	11,337		
Mar. 14	4	406	Sweet	40	61,500	Over 5½	+ .1
" 16	4	406	"	46	16,500	" 5½	+ 1 cc.
" 21	4	304	"	52	85,500	Not Performed	+ 1 cc.
" 22	4	404	"	48	33,500	Over 5½	+ 1 cc.
Average				46.5	49,250		
Apr. 4	5			41	9,100	Not Performed	Not Performed
" 5	5			45	10,300	" "	" "
" 10	5			46	6,650	" "	" "
" 12	5			45	8,750	" "	" "
Average				44.25	8,700		

* + Presence in dilution stated.
— Absence in dilution stated.

TABLE 2. SUMMER CONDITIONS

Two weeks before using the sterilizer

Date Sampled 1928	Farmer's Number	Weight of Milk, lbs.	Grade	Air Temp. at Vancouver F.	Plate Count 48 Hrs. at 37°C. Bacteria per cc.	Methylene Blue Test Hrs. to reduce	B. Coli
June 11	6	304	Sweet	61	1,360,000	Not Performed	+ .01 cc.
" 13	6	302	"	62	595,000	Within 2½	+ .001 cc.
" 18	6	194	Sweet	61	1,460,000	" 2½	+ .01 cc.
		102	Bad Odor				
" 20	6	394	Sweet	69	27,400,000	" 20 min.	+ .001 cc.
		98	Bad Odor				
Average				63.25	7,703,750		
June 11	7	294	Sweet	61	4,850,000	Not Performed	+ .001 cc.
" 13	7	174	Bad Odor	62	44,700,000	Within 20 min.	+ .0001 cc.
		100	Sweet				
" 18	7	198	Sweet	61	160,000	" 4½ Hrs.	+ .01 cc.
" 20	7	264	Sweet	69	740,000	" 1 1-3 Hrs.	+ .001 cc.
Average				63.25	12,612,500		
June 25	8	358	Sweet	63	1,310,000	Within 5½ Hrs.	+ .001 cc.
" 27	8	404	"	60	490,000	" 4 Hrs.	+ .001 cc.
July 3	8	422	"	61	930,000	" 4½ Hrs.	+ .001 cc.
" 4	8	386	"	62	675,000	" 4 Hrs.	+ .1 cc.
Average				61.5	851,250		
June 25	9	586	Sweet	63	7,700,000	Within 5½ Hrs.	+ .01 cc.
" 27	9	604	"	60	1,420,000	" 3½ Hrs.	+ .1 cc.
July 3	9	556	"	61	2,570,000	" 4½ Hrs.	+ .001 cc.
July 4	9	464	"	62	875,000	" 4 Hrs.	+ .01 cc.
		100	Sour				
Average				61.5	3,141,250		
July 9	10	100	Sweet	64	1,670,000	Within 2 Hrs.	+ .001 cc.
		94	Bad Odor				
" 11	10	102	Sweet	72	2,710,000	" 1½ Hrs.	+ .001 cc.
		100	Sour				
" 16	10	182	Sweet	65	3,300,000	" 2½ Hrs.	+ .0001 cc.
" 18	10	188	"	63	818,000	" 5½ Hrs.	+ .01 cc.
Average				66	2,124,500		
July 22	11	324	Sweet	72	350,000	Over 5½ Hrs.	+ .001 cc.
" 25	11	322	"	71	45,000	Within 1 Hr.	+ .01 cc.
" 30	11	288	"	65	462,000	" 5½ Hrs.	+ .01 cc.
Aug. 1	11	290	"	61	241,000	" 5½ Hrs.	+ .01 cc.
Average				67.25	274,500		

Two weeks during which the sterilizer was used.

Date Sampled 1928	Farmer's Number	Weight of Milk, lbs.	Grade	Air Temp. at Vancouver °F.	Plate Count 48 Hrs. at 37°C. Bacteria per cc.	Methylene Blue Test Hrs. to reduce	B. Coli *
June 25	6	264	Sweet	63	33,500,000	Within 20 min.	+ .001 cc.
"		174	Sour				
" 27	6	264	Sweet	60	47,000,000	" 1 Hr.	+ .001 cc.
		174	Sour				
July 3	6	290	Sweet	61	425,000	" 2¾ Hrs.	+ .001 cc.
" 4	6	278	"	62	1,200,000	" 3½ Hrs.	+ .001 cc.
Average				61.5	20,531,250		
June 27	7	242	Sweet	60	360,000	Over 5½ Hrs.	+ .01 cc.
" 28	7	254	"	56	1,700,000	Within 4 Hrs.	+ .001 cc.
July 3	7	250	"	61	865,000	" 4½ Hrs.	+ .01 cc.
" 4	7	246	"	62	161,000	Not Performed	+ .01 cc.
Average				59.75	771,500		
July 10	8	384	Sweet	67	2,100,000	Within 5½ Hrs.	+ .001 cc.
11	8	432	"	72	18,300,000	" 1¼ Hrs.	+ .001 cc.
" 16	8	374	"	65	146,000	Over 5½ Hrs.	+ .01 cc.
" 18	8	98	Bad Odor	63	382,000	Not Performed	+ .01 cc.
		290	Sweet				
Average				66.75	5,232,000		
July 10	9	526	Sweet	67	11,400,000	Within 1 Hr.	+ .01 cc.
" 11	9	408	Sweet	72	8,250,000	" 5½ Hrs.	+ .001 cc.
		100	Sour				
" 16	9	440	Sweet	65	360,000	Over 5½ Hrs.	+ .01 cc.
" 18	9	480	"	63	313,000	Within 1 Hr.	+ .01 cc.
Average				66.75	5,080,750		
July 23	10	184	Sweet	70	83,000	Over 5½ Hrs.	+ .1 cc.
" 25	10	174	"	71	11,500	" 5½ Hrs.	+ .1 cc.
" 30	10	164	"	65	4,900	" 5½ Hrs.	+ 1 cc.
Aug. 1	10	88	Bad Odor	61	4,900	" 5½ Hrs.	+ .1 cc.
		86	Sweet				
Average				66.75	26,075		
Aug. 6	11	262	Sweet	65	46,500	Over 5½ Hrs.	+ .1 cc.
" 8	11	304	"	68	20,200	" 5½ Hrs.	+ .1 cc.
" 15	11	238	"	62	14,400	Not Performed	+ .01 cc.
Average				63	27,033		

* Presence in dilution stated.

The Results Obtained

Table 1, the winter milk from five average farms, shows a very marked but variable, general improvement in the quality of the milk when the steam sterilizer is used. Three of the five farmers whose milk generally tested over 100,000 bacteria per cc. improved in quality so that two of them averaged around 10,000 bacteria per cc., while the third reduced his count by 50 per cent. Farmers 1 and 3, who were already shipping very good milk, still further improved the quality by using the steam sterilizer.

The general quality of the milk was such that the Methylene Blue test does not record any sample showing reduction in less than 5½ hours—a good quality milk according to this test.

The *B. coli* test also shows all the milk to be of good or fair quality, but farmers 2 and 3 show improvement by the use of the steam sterilizer.

Table 2 shows the results with summer milk from six farmers who are in most cases having difficulty in producing even a fair quality milk. This table shows under the grades given at the weigh stand that considerable of the milk was sour or of bad odor. For the sake of comparable data such milk has been included with the bacterial samples taken and undoubtedly causes many of the excessively high counts.

From first appearance Table 2 does not show any general improvement from the use of the steam sterilizer on the farm, except in the outstanding cases of the two farmers, Nos. 10 and 11, who consistently produced a high grade milk as soon as they used the steam sterilizer. On closer examining the plate counts, during the time the machine was on the farm, there is seen to be a marked difference between the counts in the first and second week. In every case the counts in the milk during the second week of using the steam sterilizer are greatly reduced and in only one case is there milk showing more than 1,000,000 bacteria per cc. Though in some of the samples of milk the daily temperature may partly account for this, there are several others where it can only be accounted for by the farmer or the labour he employed becoming more familiar with the operation of the machine; or perhaps more reconciled to its use.

The methylene blue test in general conforms with the bacterial count but the two cases of farmer No. 9 on July 18th and No. 11 on July 25th are discrepancies that cannot be accounted for. Before using the sterilizer there is only one sample recorded of over 5½ hours; on the other hand, there are nine samples recorded that do not reduce in 5½ hours when the sterilizer was in use.

The *B. coli* test, as would be expected, does not correlate with the plate count, but shows the improvement in the milk of farmers 10 and 11 when using the steam sterilizer.

Table 3, which is a summary of Tables 1 and 2, classifies all the samples of milk into four grades. This table shows::

1. That with average farmers in winter, the use of a steam sterilizer brings all the milk into the two highest grades.

2. That in summer, farmers who have been producing poor or fair grade milk will improve the quality by using steam to sterilize their utensils.

TABLE 3. *The grades of milk before and during using the steam sterilizer.*

Grade		Number of Farmers' samples of milk				Number of Farmers' samples of milk	
Quality	Plate Count Bacteria per cc.	Before		During		During*	
		Winter	Summer	Winter	Summer	1st Week	2nd Week
Very good	Below 30,000	5	0	14	5	11	11
Good	30,000 to 100,000	6	1	3	2	3	2
Fair	100,000 to 1,000,000	6	10	0	8	1	7
Poor	Over 1,000,000	0	12	0	8	7	1

*During using the steam sterilizer for both summer and winter conditions.

3. The use of a steam sterilizer during the second week, after experience has been gained in its operation, will be more effective in producing milk of higher grades.

DISCUSSION OF RESULTS

The results shown indicate the general trend of what the steam sterilization of utensils on the farm, by the farmer, will accomplish in improving the grade of normal farm milk. That there are other causes of high count milk than contaminated utensils is fully recognized and these undoubtedly play no small part in this experiment. On the other hand there is a great variation in the results shown by the different farmers in the improvement of the quality of their milk by using the steam sterilizer. This is attributed to their different attitudes of mind to steam sterilization of utensils. The efficiency of operating the machine must depend on whether or not the farmer sees any good in the process, together with the personal ability of the operator. That the significance of sterilization of utensils was not always realized is shown by the remarks of one farmer when he referred to the cans as getting so hot that they had to be cooled off with cold water. The absence of improvement in the quality of the milk of some farmers when using the steam sterilizer must be attributed to their feeling that it was unnecessary work. Therefore, education in the sterilization of utensils for the production of high grade milk must be of two kinds:

1. The appreciation of the problem.
2. The practical application.

CONCLUSIONS

Though the data presented are not sufficiently large to draw final conclusions, it may be said that there are many farmers who could produce the best grade of milk were they to steam-sterilize their utensils and carry on the same other methods as they are now using.

On the other hand, there are undoubtedly others who will not only have to adopt steam sterilizing, but also attend to other sources of contamination and adopt sound methods of cooling before they will produce high grade milk.

ACKNOWLEDGMENTS

Thanks are tendered to the Fraser Valley Milk Producers' Association, and the Department of Dairying of the University of British Columbia for

assistance and laboratory facilities which were made available for this work. To the eleven farmers who have coöperated in this work, without extra remuneration, we wish to convey our special thanks.

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BOOK REVIEW

Wheat Flour and Diet. By C. O. Swanson. (The Macmillan Co., New York, 1928. Pp. 197, illus. Price $2.50).

The appearance of this book is rather timely, coming as it does when the milling value of wheat and the place of white flour in the diet are live subjects of discussion. The first half of the book covers topics related to wheat and milling. These include an interesting outline of the history of milling and its relation to human habits of life, an excellent description of modern milling processes—a subject on which Dr. Swanson is a recognized authority, and a short discussion of the economic aspects of flour manufacture. The second half of the book is devoted to the place of white flour in the diet.

In this section the dietary requirements of the human body are discussed and the effects of deficiencies in the diet pointed out. A chapter is devoted to the food constituents of flour and its virtues and shortcomings as a food. The author sums up his case in a chapter on the relation of wheat flour to health in which he points out that while white flour is not a complete food it is a most valuable constituent of the diet and not the source of all human ills as the food quacks would have us believe.

The book is written in a popular style which is very readable and at the same time the material is accurate and instructive even for those with considerable technical knowledge of the milling industry.

J.G.M.

INSECTS AFFECTING FIELD CROPS AND GARDENS IN SASKATCHEWAN, 1922-1927*

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GENERAL STATEMENT, 1928

Apart from the brief report of Willing (1914), apparently no review of general insect conditions in Saskatchewan, during a year or period, has previously appeared, although outbreaks of a few species have been mentioned in different articles and some notes bearing on Saskatchewan conditions may be found in the several reports of the Dominion Entomologist. In this respect the entomological record for Saskatchewan has been particularly far behind those for Alberta and especially for Manitoba, for which provinces the reports of Whitehouse in the former and of Criddle in the latter make possible a fairly adequate understanding of the "normal" insect ravages. The present survey has been prepared particularly from the point of view that such reviews of occurrence and fluctuation are of value as constituting a definite record, which is then easily available to anyone who may be investigating one or more of the species involved.

During the past six years, especially the last two, rather exceptional opportunities for securing records of general distribution and relative importance of insects affecting Saskatchewan field and garden crops have been enjoyed. This has been due in very considerable measure to the information afforded through the cordial coöperation given by the Saskatchewan Department of Agriculture and the University of Saskatchewan, as well as through notes from the Dominion Experimental Farms. The statements made therefore apply with fair accuracy to the province as a whole and not merely to the district around Saskatoon. Most of the preceding records are of course based largely on variations in the amount of damage occurring, but considerable measure of the relative changes of infestation has been afforded by the periodic quantitative work continuously carried on at Saskatoon.

AGRICULTURAL FEATURES

The outstanding importance of agricultural interests in Saskatchewan, with nearly three-fourths of its population rural, as shown by the census of 1921, is widely recognized. It is not so well understood, however, that field crops are so preëminent within the province, being credited with more than five-sixths of the average annual production of agricultural wealth, nor that the current average production annually of well over three hundred million dollars value of field crops, constitutes a figure apparently not equalled for such crops in any other Canadian province. The present article which treats chiefly of the more important insect pests of field crops deals thus, with what is economically by far the most important group at present of agricultural interest.

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The present system of prairie agriculture is characterized by the high proportion of acreage devoted to a few crops, and by the importance of the summer-fallow. The growing of wheat accounts for some 60 per cent of the more than twenty million acres yearly planted to field crops (and for an even higher proportion of the value of production). With the coarse grains, oats, barley and rye, it constitutes nine-tenths of the total acreage. Flax-growing takes nearly half the remainder, leaving only a small acreage divided between the production of hay of various kinds, fodder, corn, potatoes, roots and other field crops. An additional five to five and one- half million acres annually are summer-fallowed in preparation for the next year's crop, the proportion being particularly high in the drier areas.

Entomological Conditions

These features, predicating a relative lack of crop rotation and diversification, condition the economic insect situation. Characteristically, there are a few outstanding and widespread pest species or closely related pest-groups, which account for by far the greater part of those crop losses which are due to insects. These major pests are either general feeders, or are adapted to attack the leading crops, particularly wheat.

For the six year period, considering the province as a whole, the major insect pests of field crops were (1) the wheat stem saw-fly, (2) wireworms, (3) cutworms and (4) grasshoppers. These are listed in approximate ranking in point of the crop losses which they caused, taking into account not only the abundance and potentialities of the pests, but also the degree to which practical control methods have been worked out and the extent to which they were employed.

Together with the wide acreage per farmer and the relatively low unit value of most of the crops grown on a field scale, the above features also largely condition the practicability of control measures, which for the most part must be essentially upon an ecological basis. This has been well expressed by Strickland (*20*, p. 3): "Control measures for any pest infesting field crops on the prairies must be capable of rapid application to large areas, must not call for much labor or expense and must be invariably effective." At first thought, it would appear that the widespread importance of a few major pests, would make for especial economy of entomological investigations, as permitting a general application of the results of a single worker, or of those data secured in one locality. As clearly shown by the wide variations in importance of each pest in different areas, however, there exists a great diversity in conditions in different sections of the very wide region involved, a diversity which makes requisite a study in several representative areas prior to the immediate and general recommendations of control measures based upon ecological reactions of the organisms concerned. With the above considerations, however, we are not now directly concerned, except as a background, for the present paper attempts only a record of the occurrences during the six-year period, 1922-1927.

Weather Notes

With the diversity of conditions which exist in a province of this size, it is difficult to make accurate general statements as to crop and weather conditions in any year. The rainfall of 1923 was unusually heavy and well

distributed seasonally in most of the region. In extreme contrast to this, the crop season of 1924 was the driest in very many years, in many districts constituting a record. Only the southern edge of Saskatchewan produced a good crop that year. The influence of these marked differences between the two years, upon either the direction of development or the intensity of an outbreak, was observed in several instances. In the west-central parts dry summers continued in 1925 and 1926, which in other districts were years of fair to good production. The spring of 1927 was extraordinarily late and wet in southern and central areas; the summer was also wet, the rust epidemic was heavy, and frost took a serious toll in several districts. The falls of 1925, 1926 and 1927 were unusually wet on the whole and unfavourable to harvesting operations; the relation of this to insect damage was particularly marked in 1926. Considering the province as a whole, the average crop yields were good in each year of the period, except in 1924. (The prices received were also favourable except in 1923).

Estimates of Damage

A total of nearly nineteen million dollars is estimated as the net crop loss caused by the three major insect pests of 1926. More than three-fifths of this is attributed to the heavy outbreak of the wheat stem sawfly, the remainder being about equally divided between wireworms and cutworms. The corresponding estimate for 1927 is about half that of 1926, being nearly nine and one-half millions. This large difference was connected with a marked decrease in damage by both cutworms and the wheat stem sawfly, partly offset by an increase in wireworm injury, which was somewhat favoured by the conditions of the year. Although definite general estimates for the earlier years are not available, it is believed that the losses of 1926 were the heaviest and those of 1927 undoubtedly the lightest for any year of the six.

These estimates (Table 1) were the first definite and comparable data of the sort available for Saskatchewan. They are based primarily upon the returns in the fall of each of the two years by the regular crop correspondents, from a special questionnaire sent out for the purpose by the Statistics Branch of the Saskatchewan Department of Agriculture, to whom the writer is indebted for this coöperation. The estimate of each crop reporter is based on conditions in the locality with which he is thoroughly familiar, usually including his own farm and those of a few neighbors, and not on any wide area. The estimates are thus, within the necessary allowance for the personal factor, representative "samples" of the entire province.

These estimates include, undoubtedly, only the more obvious damage by the wheat stem sawfly to wheat and of cutworms and wireworms together upon field crops in general. The allotment of the latter, as between the two pest groups, has been made as accurately as possible, using all the information at hand, but employing particularly the specialized knowledge available. Within these limitations, the general accuracy of these records, by men experienced in crop estimating, has been convincingly shown, by comparison with information received each year from some 500 independent observers, and with the results of fairly detailed entomological investigations in many of the districts. Certainly the comparative value, from year to

year and from district to district, is very high. The percentage estimates in Table 1 are believed to be, if anything, too conservative, even for the more obvious damage, since they have been scaled down considerably from the average of the returns. The dollar losses shown are net, adequate adjustment having been made for the difference between the value of ripe crops standing in the field and the value at the elevator, the latter being that shown in the usual published estimates.

TABLE 1. *Estimates of Saskatchewan field crop losses due to insect ravages.*
(A) Estimated final per cent reduction in field, from damage by the following insects—

Crop District	Wheat stem Sawfly		Wireworms		Cutworms	
	1926	1297	1926	1927	1926	1927
1	5.0	5.71	0.04	0.30	1.5	0.45
2	5.0	4.90	0.5	0.75	1.0	0.85
3	11.0	5.07	2.0	2.25	1.5	0.15
4	4.0	0.645	5.0	2.60	4.0	0.20
5	1.5	1.245	0.4	0.75	0.8	0.35
6	14.0	2.64	2.0	2.00	1.0	0.20
7	9.0	2.355	4.0	3.20	1.2	0.20
8	1.2	.48	0.5	1.65	0.5	0.30
9	2.0	1.01	3.0	2.35	2.0	0.35
Province	7.0	2.95	1.5	1.86	1.3	0.31
	(B) Estimated total loss in dollars.					
1	$ 710,000	$ 525,000	$ 16,000	$ 50,000	$ 470,000	$ 75,000
2	1,415,000	810,000	160,000	175,000	370,000	196,000
3	5,120,000	1,780,000	1,100,000	1,110,000	840,000	70,000
4	300,000	110,000	450,000	550,000	360,000	45,000
5	300,000	190,000	108,000	190,000	216,000	90,000
6	2,800,000	580,000	540,000	645,000	255,000	60,000
7	1,272,000	405,000	660,000	775,000	198,000	50,000
8	175,000	60,000	94,000	295,000	94,000	35,000
9	250,000	105,000	405,000	355,000	250,000	55,000
Province	$12,341,000	$4,565,000	$3,533,000	$4,145,000	$3,053,000	$695,000

SPECIAL FEATURES OF EACH YEAR

1922—Grasshoppers and the wheat stem sawfly were the chief pests of the year 1922, the outbreak of the former having reached its climax the previous season, while the latter was even more troublesome than usual. A feature of the year was the outbreak near Moose Jaw of the bertha armyworm (*Barathra configurata* Wlk.) on flax, constituting a new economic record.

1923—Of special interest in 1923 was the rather widespread outbreak of the northwest chinch bug (*Blissus occiduus* Barber), crop damage by which had been recorded but once previously. The total loss, however, was not great as compared with that caused by the usual major pests, wireworms being particularly troublesome. Grasshoppers were still abundant but very decidedly on the decline in point of damage. The beginnings of an outbreak of the red-backed cutworm were observed in several parts of the poplar belt.

1924—The severe and rather widespread damage caused by the six-spotted leafhopper in northern Saskatchewan was of special interest and importance. Another feature of 1924 was the beginning of an outbreak of the pale western cutworm in a considerable area of south-central Saskatchewan in which this species had never previously been recorded in economic numbers.

1925—The spring of 1925 was marked by the greatest outbreak of cutworms in Saskatchewan since 1915, the red-backed cutworm being the chief of several species. *Barathra* was very troublesome in August especially to the seed crop of sweet clover. The wheat stem sawfly and wireworms were important.

1926—Due to a combination of circumstances the damage caused by the wheat stem sawfly was the heaviest and most widespread on record. Wireworms and cutworms were also important. An interesting feature was the great abundance of the diamond-back moth.

1927—In much of the province, wireworms were the chief pest of 1927 though slightly exceeded in point of total crop damage by the wheat stem sawfly in spite of the marked decline of the latter. Injury by the Hessian fly was rather widespread but indeterminable in amount, though in the latter respect quite possibly exceeding the loss caused by the rather slight cutworm trouble of the year. The red turnip beetle, bertha armyworm and the beet webworm were abundant in some areas while cabbage worms were generally troublesome.

COURSE OF THE MAJOR OUTBREAKS

Wheat Stem Sawfly (*Cephus cinctus* Nort.). Crop injury by the wheat stem sawfly, which in point of damage caused was the most outstanding insect pest in Saskatchewan during the period, has been important each season, but with noteworthy variations. The maximum for the province as a whole occurred in the unprecedented outbreak of 1926 (Table 1 and Fig. 1)*. 1922 was also a year of heavy losses. The minimum for the six years was apparently in 1923 or 1924, with moderate damage in 1925 and in 1927 (Table 1 and Fig. 2)*.

Since 1896, when this species was first found infesting wheat (Fletcher, 7), and especially since the heavy outbreak in wheat in parts of southern Saskatchewan and Manitoba in 1907 (Criddle, 4), the area of wheat infestation by it has steadily increased in Saskatchewan. By 1922, according to reports from farmers, infestation of wheat occurred throughout the greater part of the region shown in Figure 1, although no appreciable damage was taking place in much of the northern and western areas. The outbreak of 1926 involved the heaviest losses on record in all except the eastern portions of the infested area (Table 1) and included serious damage for the first time in several of the western and north-western districts.

In the production of the marked fluctuations which have been noted above for crop losses by *Cephus cinctus,* Nort., it has been observed that at least three groups of factors are normally involved: (1) factors in spring affecting the relative rate of advancement of grains and grasses, and the production of grass stems; (2) factors influencing the rate of mortality, particularly of larvae, and (3) conditions at harvest time which determine the proportion of infested stems that fall and are lost. Of these influents, the second is undoubtedly of greatest importance normally.

Heavy precipitation in the fall or early spring, not only results in an earlier and more numerous production of larger head-bearing stems of wild

*Rate of damage based upon estimates by crop reporters.

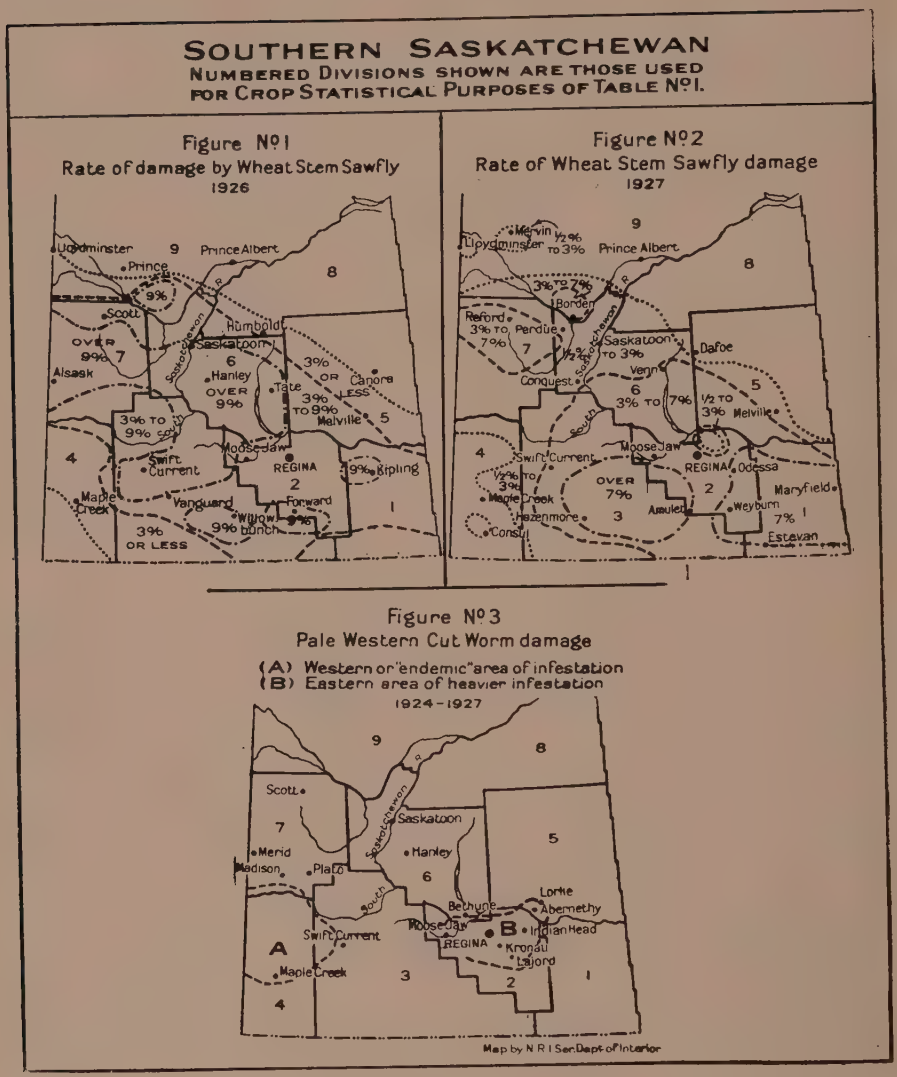

PLATE I.

and tame grasses, but also tends to retard farm operations and hence the relative rate of advancement of cereal crop growth; consequently, at the time of sawfly adult activity much of the grass is in ideal condition for egg deposition while in a high proportion the stems of small grains are too immature to be suitable. These factors were of particular importance in 1927, when an exceptionally high proportion of the eggs were deposited in grass stems.

The great importance of precipitation and soil moisture conditions, especially during the period immediately following egg deposition, in determining the rate of larval mortality, has been stated by Criddle (*3*). At Saskatoon, the adverse effect upon the sawfly of too much moisture was especially noteworthy in 1923. Moreover, in that summer, during which,

as has been noted, the precipitation was both exceptionally high and unusually evenly distributed, the effect was observed not only on the young larvae, but continuing throughout the season even after the grain was cut. As a consequence, living larvae entered hibernation in only 30 per cent of the stems originally infested, in one field of wheat under observation. In the late spring of 1924, more than two-thirds of even this relatively low population was killed by a sudden severe frost. This was the only occasion upon which mortality of this species from cold has been observed in Saskatoon. It occurred following a long, warm spell, abruptly terminated on May 20 by cold weather, during which the standard air temperature reached a minimum of 18°F. This cold weather caught the larvae, (which hibernates at the bottom of the stem and hence during that period protected by nearly two inches of earth, and usually by some snow covering), at the top of the cut stubs into which situation they had moved, preparatory to pupation, during the preceding warm weather (cf. Payne, *16*). From this low point of infestation, the numbers gradually increased, particularly in the western two-thirds of the province, during 1924, 1925 and 1926, so that the rate of infestation at harvest time of the latter year was rather high. A marked falling-off in numbers, especially in wheat, evidently took place in 1927.

The rate of infestation by the wheat stem sawfly bears no direct or constant relation to the rate of crop loss which may result. In the most favourable seasons, a very high proportion of the infested grain may be saved by the practice of harvesting "on the green side" (*3*), *i.e.* before infested stems had been cut by the grubs, while in heavy stands even those stems severed by the grubs usually are sufficiently supported by those around them to enable them to be harvested. The combination of circumstances in 1926 seems to have been the most unfavourable, from the standpoint of the proportion of crop loss to sawfly infestation, which can be envisaged and was probably of greater importance in the outbreak than was even the previous increase of infestation. Conditions observed were: (1) very considerable shrivelling* of the grain of many plants severed by the sawfly larvae, while the heads were still quite unripe, the lower stems having become prematurely dried as a result of a protracted hot period accompanied by hot dry winds just before the time for harvesting; (2) exceptionally uneven ripening of grain in different parts of the same fields, resulting from the same cause, so that few fields could be harvested "on the green side,"; (3) falling of a very high percentage of infested stems, as a result of widespread beating storms just at harvest time and the associated delay in harvesting operations; (4) complete loss of a considerable part of the fallen grain (quite a little of which was almost flat on the ground) from the sprouting which resulted from the rather long exposure to excessive moisture.

The preceding discussion, as well as the estimates of crop losses given above, deals only with the damage which occurs associated with the habit of this pest to sever the stems as soon as they become ripe. It is the writer's belief that important plant injury with consequent reduction of crop yield also occurs from the actual feeding of the larva within the stem throughout the

*Much of this shrivelling was a direct effect of the drouth, but in some instances, at least, it was materially augmented by the work of the sawfly.

season. Investigation of this point is difficult because of the fact that the adult sawflies lay their eggs in the more advanced plants, which are the early vigorous one and many of the later and weaker plants are uninfested; consequently, under normal field conditions, the infested plants appear to give the higher production.

Wireworms. Wireworms caused important crop losses during each year of the period, the more obvious damage averaging, it is believed, nearly the figures given (Table 1) for 1926. There was considerable variation from year to year both in the total damage and in the relative destructiveness in different sections, this being connected largely with varying moisture conditions. The economic situation has recently been reviewed at length (*12*).*Ludius aereipennis tinctus* Lec. and *Cryptohypnus nocturnus* Esch. were the principal species of several involved.

Spring Cutworms. The six year period witnessed the rise and fall of a serious outbreak of cutworms, reaching its climax in 1925, with low points in 1921 or 1922 and again in 1927 (or possibly 1928). The course of the general outbreak was largely determined by the changes in numbers of the red-backed cutworm, though the pale western cutworm was a factor of considerable importance in parts of southern Saskatchewan, particularly in 1926 and 1927. Another important outbreak was that of the early cutworm (*Euxoa tristicula* Morr.)in 1925 (*8*) apparently the first record of serious damage by this species. The army cutworm (*Chorizagrotis auxiliaris* Grt.) was abundant in southwest Saskatchewan in 1926 as a part of the heavy outbreak also present in southern Alberta; it is believed that this species was again fairly abundant there in the spring of 1927, but little or no damage occurred. *Sidemia devastator* Br. in 1923 and *Feltia venerabilis* Wlk. in 1924 were of moderate economic importance.*

In the light of the more definite and authentic figures for 1926 (Table 1) it is evident that the tentative estimate previously suggested (*8*, *11*) for 1925 was very much too conservative and that the losses caused in Saskatchewan by cutworms in that year probably exceeded eight million dollars. Nearly three-fourths of the three million dollar cutworm damage of 1926, and an even higher proportion during the earlier years of the outbreak is attributed to the red-backed cutworm and its allies. Losses amounting to some three-quarters of a million dollars were caused by the pale western cutworm in 1926, and probably nearly an equal amount in 1925; nearly three-fifths of the estimate for 1927 is attributed to this species; these losses were about equally divided between the western and eastern infested areas discussed below.

Red-Backed Cutworm (*Euxoa ochrogaster* Gn.) and Allies. The history in Saskatchewan of previous outbreaks of the red-backed cutworm and of the last outbreak up to its climax in 1925, have been reviewed (*11*). No field crop losses were reported for 1922, but in 1923 damage occurred in small areas in several localities within the savanna (poplar) belt, particularly in the north. The infestation of 1924 was on the whole moderate, but the amount of damage was greatly augmented by the very dry conditions. The conditions of 1924 were largely responsible also for the un-

*A full list and brief discussion of each of the cutworm species which have been troublesome in the Saskatoon district during the period is to be given in a later paper.

usual intensity of the 1925 outbreak. The general infestation was much reduced in 1926, but was heavy in south-east Saskatchewan where, as in Manitoba*, the outbreak reached its climax in that year, the damage being increased by a dry spring. Also in line with the history of previous outbreaks (*11*) there were local infestations in 1926 in many parts of the area lying south-west of the general boundary between savanna and prairie. In 1927 damage to field crops by these cutworms occurred only in scattered and isolated fields. *E. ochrogaster* has been by far the most important of this group in Saskatchewan, but with it were associated *E. tessellata* Harris and several lesser species of similar habits and appearance. *E. messoria,* which was abundant in eastern Manitoba in 1926 (*14*) has not been encountered here in economic numbers during the past six years.

Pale Western Cutworm (*Porosagrotis orthogonia* Mort.). The data at hand strongly indicate that there has been a marked northward and eastward spread in Saskatchewan within recent years, both in the actual range of this cutworm and in the area subject to economic infestation by it. Prior to that time recorded outbreaks had been largely confined to an endemic area in south-west Saskatchewan in which the soil and average weather conditions favour the maintenance of this species in some numbers. This area (Fig. 3) includes approximately the districts from the Cypress hills north to the South Saskatchewan river or a little beyond and from the Swift Current district west to the Alberta boundary, connecting with the large endemic area in southern Alberta. During 1920, which was the culmination of a series of outbreak years, damage was recorded nearly as far east as Regina.‡

During the general cutworm outbreak of 1925, fields heavily infested by this species were discovered in the district from Indian Head to Abernethy (Fig. 3). In 1926 this district was again severely affected, but even more extensive damage was found around Kronau and Lajord. The most heavily infested area of 1927 was around Regina and westward, though the Abernethy district yet again suffered considerably. The full extent of the area in which damage occurred during this period is not definitely known, but approximate boundaries of the parts most severely affected may be indicated (Fig 3) from existing data.

Investigation and inquiry have brought out that the first noticeable damage to field crops in much of this south-central (eastern) area occurred in 1924, but was not serious until after that dry year. The peak of damage was reached in 1925 or 1926. Heavy infestations occurred widely in 1927 but, as in the western area, the rate of injury was very greatly reduced by the exceptionally wet spring and serious damage occurred for the most part only to late-seeded crops, chiefly oats and barley.

In contrast to conditions in an endemic district during an outbreak year, in this eastern area only occasional fields were heavily infested. Within such fields, however, the larvae were often extremely numerous, so that in some instances, where the farmers were unfamiliar with the habits of the new pest, as many as three or four seeding of wheat were completely des-

*Norman Criddle, personal communication.

‡S. H. Vigor, personal communication; see also map given by Seamans (*18*). No damage has been authentically recorded south of the Cypress hills in southwest Saskatchewan.

troyed in succession. In confirmation of the experience elsewhere it was found that heavy infestations occurred only in fields where the soil crust had been disturbed during the period of moth flight the previous summer. Quite in line with this were the rather well established observations of the occurrence of especially important infestation following early fall ploughing.

Likewise, it was observed that the method of control in summer-fallow by leaving it untouched from August 1 to September 15 as recommended by Seamans (*19*) was equally as effective when it could be employed in the newer as in the older infested areas. In the former, however, agricultural and environmental conditions differ widely from those in the latter, summer-fallowing is employed irregularly and at considerable intervals and the greater number of the heavily infested fields had been in crop the preceding season. Then too, the weed growth in this eastern area is very heavy, making it not always practical to keep off the fallow for the full period necessary for pale western cutworm prevention. It seems evident that control will be an especially difficult mattter there, should the species become a regular pest. Such a development is not anticipated; the soil through most of the eastern infested area is a heavy silt-clay, in contrast to the rather light sandy loam of the endemic area, and the average climatic conditions are distinctly unfavourable to this species, judging from its reaction elsewhere. It is expected therefore that *P. orthogonia* will be a pest in the eastern area, only during occasional periods in which May and June are unusually dry.

An especially interesting feature of the recent eastern outbreak was that the character of the response to weather factors seemed to have been somewhat abnormal, suggesting the possibility that the cutworm for a time largely outdistanced its natural enemies; these apparent differences may, however, be reconcilable when the data are more thoroughly studied. The marked increase of the species during the very dry season and its maintenance as a result of the early season and dry May of 1925 was a normal reaction. The weather conditions of 1926 would normally, it is tentatively considered, have caused a considerable reduction in this area in numbers of this cutworm; yet the infestations of 1927 were apparently fully as heavy as those of the earlier years. The very wet year of 1927, however, seems to have put a definite stop to the outbreak. Until the last year the parasitism, as revealed by quantitative collections (*12*) of nearly mature larvae has been very low and the virtual absence of *Gonia* spp., normally the chief parasite of this cutworm (*20*), was especially noteworthy. In 1927 a heavy larval and pupal mortality was revealed averaging (in collections of nearly mature larvae) at least 70 per cent; *Gonia brevipulvilli* Tothill (determination by C. H. Curran) was the most important parasite destroying as high as 40 per cent, but parasitism by *Paniscus* sp. was exceptionally heavy, running more than 20 per cent in some fields. An interesting feature was the marked importance of disease, which accounted for at least 60 per cent of the maturing larvae, and some of the pupae, in one field.

In addition to the general areas shown on the map (Fig. 3) moderate damage occurred in 1925 as far northeast as Saskatoon and Hanley; at Madison in 1926, and at Merid in 1927, all being new economic records. The data for Saskatoon are particularly significant of the spread already referred to since the work of several collectors had never revealed the presence of the

species here prior to 1922 and light trap records show a steady increase from that time until the first larval and economic record in 1925.

Grasshoppers. The economic features in Saskatchewan of the great grasshopper outbreak from 1918 to 1924, have been described by Tullis (*21*) under whose direction the extensive control campaign was organized. The maximum intensity was reached in 1921 but had only slightly decreased in 1922. The infestation was very much less in 1923 and by the next year the grasshoppers had largely disappeared except in a few small districts. In this sharp decrease, a variety of parasites and predators, chiefly insects, were involved, as well as disease, which were of outstanding importance at Saskatoon and in many other districts during the wet season of 1923. The principal locusts involved (*5*) were *Melanoplus atlanis* (Riley) and *Camnula pellucida* (Scud.) with *M. bivitattus* (Say) and *M. femur-rubrum* also of considerable importance. Limited observations by the writer indicate that *M. infantilis* Scud. and *M. packardii* Scud. were also quite troublesome in some fields during the latter years of the outbreak. Reports received during the fall of 1927 from an area centering on Swift Current in southern Saskatchewan suggest that economic grasshoppers may again be on the increase.

Due to the nature of the pest and the very efficient organization of the campaign a high proportion of the potential ravages of the last outbreak were controlled. Consequently, the total of the actual losses and the cost of the campaign were relatively low both in proportion to the possible losses, if uncontrolled, and in relation to the importance of the outbreaks as compared with those of the other pests just discussed, damage by which is at present reduced only to a moderate extent by the employment of artificial control measures.

OTHER INSECTS ABUNDANT IN FIELDS.

Bertha Armyworm (*Barathra configurata* Wlk.). Since its first economic record at Moose Jaw in 1922, this armyworm or climbing cutworm has been troublesome each year during late summer, seriously affecting fields of flax, sweet clover, alfalfa, cabbage and corn, among other food plants (*9*). The heaviest infestation in Saskatchewan occurred apparently in 1925, but during the past season the outbreak involved not only several districts in this province, but was particularly severe in Alberta and extended in southwest Manitoba.

Northwest Chinch Bug (*Blissus occiduus* Barber). A rather heavy but localized outbreak of this species, for which the name northwest chinch bug is proposed, was discovered in 1923, through Wm. Broadfoot, then District Representative of the Provincial Department of Agriculture. A considerable area in west central Saskatchewan, centering on Plato, was affected and a number of acres of wheat were completely destroyed. That was the only year in which damage was observed and is of interest as the first record even of occurrence in this province and the second of economic importance of the species (*15*). The subsequent sharp drop in numbers seemed to result from the combined effects of the wet conditions of 1923 and of a very severe frost late in May 1924, which killed a large quantity of the over-wintering nymphs which had previously become very active.

Six-Spotted Leafhopper (*Cicadula sexnotata*). This insect was a pest of major importance in 1924 over a considerable area in northern (agricultural) Saskatchewan, from Saskatoon north. Numbers of 25,000,000 per acre were encountered in late summer; yields of oats and barley in particular were very seriously reduced, supplementing or even exceeding the effect of lack of moisture. Lettuce and other garden crops were also much affected. Investigations indicated that this unexpected and heavy outbreak resulted from a general increase in infestation, evidently largely connected with the wet season of 1923, followed by a concentration in grain fields when the native breeding areas dried up during the dry season of 1924. In 1925 the species was conspicuous by its virtual absence.

Hessian Fly (*Phytophaga destructor* Say). The Hessian fly was abundant in 1927 over a widespread area, damage by the second brood being reported especially in large districts around Moose Jaw and Scott. This was probably the heaviest damage during the period, though several reports were received also in 1922, 1923 and 1925. The chief outbreak of 1925 was in southern Saskatchewan, evidently an extension of the unusual infestation of 1924 reported in Montana (*1*, p. 25) and western North Dakota. The data, particularly those bearing on the first brood, are too meagre to indicate the real importance of the pest, but it is believed that it is responsible for considerable losses in some years, the work in the spring probably being popularly attributed to either cutworm or wireworms. The observations in Saskatchewan are entirely in confirmation of Criddle's statement (*2*), both the rate of infestation and the relative importance of the partial second brood increasing in wet years and decreasing in dry ones.

Wheat Stem Maggot (*Meromyza americana* Fitch). Adults of the wheat stem maggot were very commonly represented in collections made on grassland, both native and tame. Wheat plants injured by this species are also encountered rather frequently, but the extent of its depredations are not definitely known. Damage to the extent recorded by Webster (*23*) in North Dakota has not been observed in the vicinity of Saskatoon, but may occur in the south of the province.

English Grain Aphid (*Macrosiphum granarium* Kirby). The prevalence of frost and rust injury in 1927 drew especial attention to the crop in August and was doubtless in part responsible for the unusual number of inquiries relating to sphingid larvae, occurring incidentally in fields, and to the English grain aphids, which were very numerous on the heads. Both of these, particularly the latter, were, however, generally more abundant than usual. This aphid was also common in 1923 and occurs in moderate numbers each year chiefly in prairie districts. The exact economic status here of this aphid is not clear, although almost undoubtedly considerable damage occurs when it is abundant as in 1927, notwithstanding the fact that it does not normally appear in large numbers until the crop is nearly mature.

Green Bug (?). An interesting feature of 1926 was the abundance late in the summer of an aphid on grain in parts of the wooded area of eastern Saskatchewan. In some instances the aphids were reported to be so abundant on grain as to cover the binder canvas and retard harvesting opera-

tions. A correspondent, S. B. Holloway, of Lorlie, Sask., stated that early sown fall rye was completely destroyed by these aphids, while that sown later escaped serious injury. Unfortunately, specimens were not secured for determination, but it is strongly suspected that the species involved was *Toxoptera graminum* Rond, in view of the area affected, the type of damage the crops affected, and of the unusual outbreak of that species in Minnesota (*17*) and Manitoba.

Beet Webworm (*Loxostege sticticalis* L.). The beet webworm seems again to be on the increase. Prior to 1926 no damage by it had been recorded since the great outbreak of 1917-20 (*6*). In 1927 it was abundant in eastern, central and west-central districts. As usual, the insects fed chiefly on weeds and, although considerable popular interest was excited, little damage was reported except to gardens and to a single field of sunflowers at Bethune.

Diamond-Back Moth (*Plutella maculipennis* Curt.). A general outbreak of diamond-back moth, which was observed in its early stages in 1922 and 1923 in southern Saskatchewan, reached its climax in 1925 and 1926, breeding on both wild and cultivated crucifers. While not a pest of field crops, much popular interest was aroused in 1926, in the districts badly infested with wild mustard, by the occurrence of large numbers of the cocoons on the ripening heads of grain. No feeding occurred there and the very heavy rate of parasitism of these cocoons by *Sagaritis* spp. especially *congregator* Walley (*22*) suggests that the migration resulted in part from this stimulus as well as from a scarcity of food. In that connection it is interesting to note that the species evidently was not troublesome in those areas the following year. The infestations on cabbage were very heavy in 1926.

Red Turnip Beetle (*Entomoscelis adonidis* Pall.). The red turnip beetle likewise is not, in the main, a field crop pest though occurring widely on cruciferous weeds in such fields. In the garden, considerable damage is done especially to the turnip. The species has been on the increase for two or three seasons and the outbreak of 1927 apparently was one of the most widespread on record, not only occurring as usual in the poplar-savanna belt, but extending far out into the prairie. It is suspected that the changes in abundance may be connected in a considerable measure with moisture conditions affecting the amount of desiccation of the eggs during the period of hibernation; the species may also be favoured by dry conditions in summer, as suggested in Europe.

Other Species. The salt marsh caterpillar, *Estigmene acraea* Drury, was rather abundant in 1923, attacking sweet clover. The combined effect that year of a prevalent disease of the larvae, and the high parasitism by the tachinid, *Sturmia albifrons* Walker, greatly reduced its numbers and it has not been of observed importance since, though probably involved in one report of damage near Saskatoon late in 1927. The spinach carrion beetle, *Silpha bituberosa* Lec., was likewise common in 1923, causing appreciable harm to small fields of mangels, beets in gardens, and also numerous on lamb's quarters, which is its commonest host plant. The sunflower leaf beetle, *Zygogramma exclamationis*, (Fab.) occurred in large numbers in 1925 when it caused considerable damage; the numbers were rather low in

1926 and no reports were received in other years of the period. A similar sudden and marked increase, probably also for but a single year, was observed in 1927, in the instance of *Zygogramma conjuncta* Rogers, which attacks poverty weed (*Iva axillaris* Pursh.) The false chinch bug is often abundant in field crops and occasionally injurious (see below).

Garden Pests

If only the cash value of total production is considered, garden crops are as yet of little importance in Saskatchewan, relative to field crops. This is by no means the sole criterion, however. The much higher rate of damage by insect pests, the greater possibilities of control, the grower's more intimate contact with and more immediate interest in their garden, all combine to increase considerably the standing of insect pests of vegetables and small fruits.

The most destructive insect pests of garden crops are the cutworms. This is especially true of the red-backed cutworm, which has a marked feeding preference for broad-leaved plants. It normally maintains itself in gardens and (in the poplar belt) is seldom in such small numbers that its presence there does not result in appreciable damage. In wireworm districts this pest is a serious enemy of the garden, particularly damaging lettuce, potatoes and corn. It has been noted that several others of the species already discussed are either primarily or secondarily pests of the garden.

Colorado Potato Beetle (*Leptinotarsa decimlineata* (Say)). Throughout the southern third or half of the agricultural area, the Colorado potato beetle is an important pest of the potato, and normally at least one application of an arsenical poison is required to prevent destruction of the vines. The infestation has shown within the past ten or twelve years a definite northward spread, which apparently has now reached its limit; isolated adults have been reported from as far north as Prince Albert. At Saskatoon, where appreciable damage occurred for the first time in 1923, the species now occurs normally in small numbers and sometimes is abundant enough to require control measures in occasional gardens. Marked fluctuations in the intensity of infestation occur from year to year in the northern limits of occurrence. Many of these are quite obviously correlated with the amount of snow coming during the preceding winter, a fact pointed out many years ago by Criddle. A particularly striking instance of this occurred recently in southeast Saskatchewan. In 1925 this pest was abundant and destructive; in 1926, folowing a winter of relatively light snow covering, it was so scarce that almost no one undertook control measures.

White Grubs (*Phyllophaga* spp.). The larvae of *Phyllophaga* spp. have been an almost negligible factor in the production of either field or garden crops, though occasionally common in eastern Saskatchewan. The only damage by them which has been reported during this period occurred in 1925 to potatoes in that area.

Cabbage Worms. At least four species have been destructive to cabbage and cauliflower during the period. *Plutella* was the chief species in 1926 and in several instances virtually ruined the crop. *Barathra* was outstanding in 1925 and was also an important factor in 1926 and 1927. The imported cabbage worms (*Pieris* spp.) were usually the most numerous, though they occurred only in moderate numbers except in 1922 and 1927

when exceptionally abundant. The native species, *P. occidentalis* Reck. have been fairly constant in numbers, and the fluctuations seem to have been induced largely by the imported species *P. rapae* L., which, after being abundant in 1922 and part of 1923, was quite scarce for two or three years; the cause of this is not known but it is expected that several factors were concerned. The destructiveness of the cabbage worms has been unnecessarily great as the growers have not been accustomed to using control measures as a routine practice; such a step was indeed unnecessary until a comparatively recent period.

Cabbage Aphids. These aphids have been fairly abundant on several occasions, being particularly annoying on cauliflower, but control measures have seldonm been undertaken.

Cabbage Root Maggot (*Hylemyia brassica Bouche*). The cabbage root maggot is of greater importance than the cabbage aphid. It is normally troublesome to late plantings of radish and was particularly injurious to cabbage and turnips in 1923 and the early part of 1924. This insect seemed scarce in 1926.

Onion Maggots (*Hylemyia antiqua* Meig.). The onion maggot occurs apparently throughout the agricultural area and is destructive nearly every year. Reports of damage were particularly widespread and numerous in 1925. The control measures normally recommended all seem too cumbersome for the small garden and the maggots continue to take very heavy toll.

Seed-Corn Maggot (*Hylemyia cilicrura* Rord.). Adults of the seed-corn maggot are among our most common representatives in quantitative work, both in native and in ruderal surroundings. Doubtless appreciable damage to the seeds and growing plants of various crops occurs in some years, but to what extent is not known. These same maggots have been found rather heavily attacking the roots of well-grown Caragana, apparently following on severe injury by excess soil-moisture in low-lying spots.

Corn Earworm (*Heliothis obsoleta* Fab.). The corn earworm is not normally a pest in Saskatchewan but considerable injury to late sweet corn occurred in southern districts in 1927; the only record of this during the period. Similar injury by *Barathra* was much more widespread.

Blister Beetles. Representatives of this group cause some damage to garden beans every year in some locality. They were particularly injurious for several years just before and after the close of the grasshopper outbreak, appearing in great abundance in alternate years and in somewhat lesser numbers during the intervening ones. 1924 was a season of particular abundance of the adults. *Lytta nuttalli* Say has been the most abundant species, particularly on garden beans and Caragana, but *L. sphaericollis* Say and *Macrobasis subglabra* Fall. have been very common on Caragana and honeysuckle.

False Chinch Bug (*Nysius ericae* (Schill)). The false chinch bug, a species common in native situations, has also been injurious to a variety of plants in gardens, chiefly in a wide area in the southwestern part of the province. Damage was reported in 1923 and especially in 1924. In the latter year some loss was caused also by their attack on wheat, particularly when clustering on the heads just before ripening.

Currant and Gooseberry Insects. Bush fruits, which are very commonly grown even in the smaller gardens, are subject to severe injury by four insects attacking the foliage and fruit. The imported currant worm, (or sawfly) (*Pteronidea ribesi* (Scop.)) and the currant aphid (*Myzus ribis* L.) are almost universally distributed in the province and are troublesome every year. Both seemed especially abundant in 1925 and 1926 while the latter was even more commonly reported in 1927. The currant spanworm *Itame ribearia* Fitch., was encountered in 1927 at several points in west central Saskatchewan, these being the first reports of its occurrence here, although undoubtedly present for a few years before. Where observed it was in large numbers, completely defoliating the plants within a few days after it first became noticeable. The observed infestations were on red currant, and gooseberry was attacked only by larvae migrating from that plant.

Black currant has evidently suffered less seriously from the above species than have the other varieties, but all are severely attacked by the currant fruit fly, *Epochra canadensis* Loew. This species is apparently subject to wide variations in numbers, for, after having been rather scarce in most gardens for several years, noteworthy infestations occurred in 1926 and especially in 1927, in the vicinity of Saskatoon.

Relative Hazards to Various Crops

The rate of insect injury to wheat is much greater than for any other of the small grains. In a considerable measure this fact is directly connected with the tremendous acreage devoted to it and its frequent use in successive years in the same field, thus permitting multiplication of specific pests such as the wheat stem sawfly, "commercial" injury by which is largely confined to this crop. The powers of recovery of young injured plants seems relatively low and wheat suffers with especial severity from the ravages of wireworms and cutworms, the extent being materially increased, with the former pest, by the almost invariable use of this crop immediately after summer-fallow.

Oats suffer relatively little from insect pests, though the somewhat later average date of planting often results in an especial severity of attack by cutworms, particularly the pale western species. Appreciable damage by wireworms occurs also in wet springs. Fall rye has very seldom suffered severely from insect ravages, insofar as has been observed, a fact which adds to the usefulness of the crop.

Because of the relatively small number of plants per acre, corn is subject to much more severe damage by wireworms and cutworms than are the other cereal crops. Sunflowers, however, are more resistant than corn, and except for a moderate amount of destruction by cutworms in outbreak years, and generally slight injury by leaf feeders, have suffered very little. Ear injury even to sweet corn is usually negligible at present.

Flax and sweet clover are subject to very extensive destruction by the red-backed cutworm and other cutworms of similar habit, but this is partially compensated for by their special resistance to wireworm attack, though the former crop is by no means entirely immune to injury by this pest. The luxuriant growth of sweet clover minimizes the attack of leaf-feeding insects, but, when grown for seed, this crop, in common with flax, may suffer very severely from *Barathra*.

Although the yield of cultivated grasses undoubtedly is considerably reduced at times, especially by the attack of leafhoppers, oscinid maggots and aphids, the more important entomological relation of these crops is as a breeding ground for pests of other crops, particularly wheat. The belief seems well founded, that western rye grass (*Agropyron tenerum* Vasey) is especially culpable in this.

Among garden crops, onions normally suffer most severely at the present time, although cabbage losses are nearly as severe, and, in the area normally infested by *Entomoscelis,* turnips are not far behind in respect of insect damage. It has been noted that insect attack on potatoes is relatively low, especially in northern Saskatchewan. Except for the work of general feeders, tomatoes, strawberries, beets, carrots and most other garden vegetables and small fruits suffer very little from insect ravages at the present time.

Summary

A general review is given of insect pests affecting Saskatchewan field and garden crops, during the past six years, with special reference to the more outstanding fluctuations in abundance or in crop damage. The features of outstanding interest or importance are discussed with particular attention to the major pests and to information not previously reported. All of the species known to have been of economic standing during the period are mentioned.

Estimates of more obvious crop losses caused by the major insect pests in 1926 and 1927 are presented. An appraisal is attempted of the relative normal insect hazard to the various crops; it is concluded that wheat, the most widely grown and valuable crop, suffers much more severely than do any other of the more important field crops.

It is noteworthy that nearly all of the major insect pests and most of the minor ones are species native to the original prairie or savanna environment, but which now normally attack cultivated crops. As far as is known, all of the other pest species have gradually spread in, from adjacent areas previously infested, with the introduction of their host plants.

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A STUDY OF NITRATE PRODUCTION IN VIRGIN SOILS OF ALBERTA*

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INTRODUCTION

The four virgin soils herein discussed are characterized by a noticeable variation in organic matter content. Three of them—the mineral soils—have the inherent ability to produce high yields of cereal crops under their particular optimum climatic conditions.

The object of this investigation was to make a comparative study of the rates of decomposition of the organic matter by measuring micro-organic activity as reflected by bacterial numbers and nitrate nitrogen.

EXPERIMENTAL

THE AREAS OF THE SOIL BELTS INVESTIGATED

(1) The Brown Soil Belt—Prairie.

The semi-arid plains area is characteristic of South-eastern Alberta, and contains approximately thirteen million acres. The annual precipitation averages 12-14 inches.

(2) The Black Soil Belt—Parkland

The "Parkland", so designated because of the promiscuous distribution of small groups of poplar and willow, occupies an area of about seven million acres in Central Alberta, and enjoys a precipitation of 16-18 inches.

(3) The Timbered Soil Belt.

This wooded area encompasses about two-thirds of the entire province beginning at latitude 50 north and extending in a northerly direction. The climatic conditions are similar to those dominating vegetative growth in the black soil belt area.

(4) Peat or "Muskeg" Areas.

Within the timbered soil areas there are present extensive areas of "Muskeg", or Sphagnum Peat.

Attention is drawn to the fact that the sample of timber soil used was representative of the best in the province and consequently shows a high organic matter and nitrogen content.

METHODS

The soils were air dried and, with the exception of the Peat, sifted through a coarse mesh sieve.

The optimum moisture was reckoned on the basis of 60 per cent of the soils' water-holding capacity.

The hydrogen-ion concentration of the air dried soil was established by the colourimetric method, using Clark & Lub's system of indicators.

One hundred grammes of soil were placed in jelly jars in triplicate.

Incubation was at room temperature for definite periods of 1, 2, 3, 5, 8, and 11 weeks. At the end of each period the soils were dried at 80°C.

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for sixteen hours, excepting sufficient soil for microbial counts. The dried soils were then ground to pass an 80 mesh sieve, stored in sealers and later analysed for nitrate nitrogen by Harper's modified phenol-disulphonic acid method. Slight modifications were necessary to clear the extract obtained from peat. Time of initial shaking was increased 50 per cent and the supernatant liquid filtered instead of decanting. The coloured extract was generally more intense than in the mineral soils necessitating an increase of carbon black to 2 per cent.

Micro-organic counts were made in triplicate, and the following media used, sufficient of which was made up at the beginning to last throughout the experiment.

(*a*)—*Bacterial Counts*—Beef extract-peptone-agar.

(*b*)—*Fungi*—A medium having a pH 4.0, and proposed by Waksman (*5*).

(*c*) *Actinomyces*—A synthetic medium proposed by Waksman (*4*).

Counts were made at the end of seven days.

Circumstances were opposed to making counts of fungi and actinomyces throughout the entire duration of the experiment.

Total nitrogen was determined by Gunning's modification of the Kjeldahl method.

An experiment was later carried out to check the variation in the medium used for bacterial counts, by using a synthetic medium proposed by Conn and later modified by Thornton. The variations were insignificant.

Results

At the outset we are concerned with the quantity of organic matter and other factors conditioning decomposition in the respective soils.

Table 1. *Total nitrogen, organic matter, and pH in the four soil groups.*

Soil Group	Organic matter in soil* (per cent)	Nitrogen in soil (per cent)	Nitrogen in organic matter (per cent)	Ratio Nitrogen to organic matter	pH
Prairie	7.18	.240	3.34	1 :29.9	6.6
Park Belt	27.08	.918	3.39	1 :29.5	6.8
Timber	22.22	.609	2.74	1 :36.5	6.9
Peat	93.13	.800	.87	1 :116.4	3.5

*Determination of organic matter by ignition.

The addition of water to an air dried soil will cause a more rapid interchange of nutrients and consequent micro-organic activity. Observation of Table 2 indicates that the bacterial numbers of the two mineral soils, Timber and Parkland, are along parallel lines, and although a similar analogy is not possible in the Prairie soil because of the absence of sufficient soil for the whole period of the investigation, nevertheless the progressive increases shown at the periods indicated are coincident with the zenith of the curves for the other two mineral soils. There is also a striking similarity in the rhythmic fluctuations of the fungi and actinomyces.

It has been shown that protozoa are practically universally present in soils (*3*); their presence has been qualitatively demonstrated in the soils under investigation.

The micro-organisms of peat cultured on media similar to that utilized in the differentiation of the three groups, bacteria, fungi and actinomyces,

TABLE 2. *Microörganisms, millions per gram of soil in the four soil groups.*

Incubation in weeks	Microörganic group	Prairie*	Park Belt	Timber	Peat
	Control	.10	2.16	1.37	.03
1	Bacteria	-----	3.34	4.89	1.26
	Actinomyces	-----	-----	-----	-----
	Fungi	-----	-----	-----	-----
2	Bacteria	2.60	1.60	1.65	1.60
	Actinomyces	-----	-----	-----	-----
	Fungi	-----	-----	-----	-----
3	Bacteria	-----	1.60	1.61	1.57
	Actinomyces	-----	.29	.28	.09
	Fungi	-----	.14	.11	.19
5	Bacteria	5.20	3.22	4.95	1.57
	Actinomyces	.46	.58	.69	too dense to count.
	Fungi	.05	.07	.12	.15
8	Bacteria	-----	1.57	1.61	3.12
	Actinomyces	-----	.15	.14	.13
	Fungi	-----	.28	.39	.14
11	Bacteria	7.68	12.10	3.28	1.67
	Actinomyces	.92	.46	.52	.13
	Fungi	.11	.33	.50	.37

*Only three incubation periods were possible owing to insufficient soil.

in the mineral soils, show characteristic growth in the three media, of one group, the fungi. The high hydrogen-ion concentration of the peat suggests that they dominate the biological activity therein, which observation we shall see later is substantiated by a measure of nitrification. This not only suggests that there is a wholly different ratio of micro-organisms present but indicates a biological adaptation of one group to a wide range of hydrogen-ion concentration, for the three media used corresponded to a pH 7.0 for the isolation of bacteria, pH 5.75 for actinomyces, and pH 3.9 for the fungi.

Reference to Table 2 indicates that there is a fairly close analogy in the numbers of micro-organisms within the four soil groups. It is particularly noticeable that the population of the raw sphagnum peat, a very unfertile environment for normal plant growth, stands in a direct relationship with the mineral soils, a condition, in the writer's opinion, that is not justified by subsequent experimental evidence herein reported covering nitrification as a measure of fertility.

Reference to Table 3 indicates that there was a steady increase in the accumulation of nitrate nitrogen in the three mineral soils, but that of peat was anomalous.

TABLE 3. *Nitric nitrogen, parts per million of soil.*

Period of incubation weeks	Prairie	Park Belt	Timber	Peat
Control	2.26	2.66	3.54	17.60
1	-----	10.87	15.62	82.14
2	14.70	20.27	58.82	69.44
3	-----	27.77	58.82	24.27
5	30.00	35.71	83.33	24.76
8	-----	57.69	133.33	22.92
11	41.66	66.18	166.66	22.72

It is evident from these results that there is no dearth of nitrate nitrogen in our mineral soils when it is considered that approximately 58 lbs. of

nitrate nitrogen per acre are required to produce a thirty bushel crop of wheat, but a similar condition does not pertain to our peat soils.

The irregularity in the case of peat, particularly the zenith point corresponding to the first week's incubation, offers an interesting field for further investigation, inasmuch as the results of the initial period of incubation indicate an inherent ability to rapid nitrification. The writer offers the suggestion that this fluctuation may be accounted for by desiccation of certain groups of the micro-organic population, as for instance, fungi, and the inactivation of protoza, in the process of air drying of the sample previous to the commencement of the experiment. These organisms directly or indirectly assimilate nitrates to satisfy their physiological requirements, and by reason of the displacement of the microbial groups, while the samples are being air dried, bacterial numbers increase, for their moisture requirements are relatively small and the pH of the environment is enhanced by accumulated ammoniacal compounds. The process reflects a condition of partial sterilization. The addition of water permits at first of rapid nitrification. Then the germination of fungal spores and the excystation of protozoa with a consequent displacement of bacterial dominancy, results in assimilation of nitrate nitrogen, particularly after the second week of incubation.

The inspection of Table 3 wherein the computation of nitrates is upon the basis of the soil as a whole, would lead one to suppose that a certain obvious order of the rate of nitrification existed within the soil groups, but in the writer's opinion this position cannot be supported by the related factors, biological activity and organic matter present.

DISCUSSION

The Inter-Relationship of Factors: Organic Matter—Bacterial Numbers—Nitrate Nitrogen

There has been a progressive increase in the amount of nitrate nitrogen accumulated in the three mineral soils for each succeeding incubation period, a reflection of biological activity and the source of energy—organic matter.

Bearing in mind that we have three inter-related factors: Organic Matter, Bacterial Numbers, Nitrate Nitrogen, the question naturally arises whether any correlation can be found between them.

The energy for synthesis of cellular material and for physiological functions is obtained from the organic matter. The quantity, composition, and nature of that material per unit of soil must influence the ratio of biological group activities in soil. With this variable factor always constituting a part of the integral unit—the soil as a whole—which it is customary to use as the basis of calculation for comparative purposes, it is very evident that by no rational reasoning can there be seen any correlation between the soil as a whole, its microbial population, and products of metabolism, for one of the factors contributing to a condition of soil fertility is the *rate* at which plant nutrients are made available, a reflection of micro-organic activity and its source of energy.

No correlation being possible between the soil aggregate and these fundamental factors—micro-organisms and organic matter—the relevancy of the method for comparative purposes is questioned.

Organic Matter

The ratio of certain organic compounds in the organic matter must play an important part in micro-organic decomposition, and we may question the significance of viewing the subject from the standpoint of so much nitrogen per hundred grams of soil. Observe for instance the percentage nitrogen of the four soils under experiment, Table 1. The figures inform us that the total nitrogen varies in the different soils and incidently that there are variations in the organic matter content, and it might even be asserted that because there is .8 per cent total nitrogen in the peat it ranks alongside the fertile mineral soils in its quantity of nitrogenous material and the activity of its organic matter. As a matter of fact, in the writer's opinion, there is no comparison between them. Instance for example the case of the semi-arid soil and peat—Table 1. In the former there is .24 per cent nitrogen from 100 gr. of soil containing 7.18 per cent organic matter. Now the nitrogen, of whatever form it may be in—organic or inorganic—is from organic material, so that the quantity of nitrogen is not derived from 100 gr. of soil but from 7.18 per cent and it is upon this basis that the calculation should be made. Under this condition the nitrogen of peat ranks extremely low, .87 per cent as against 3.34 per cent of the Prairie soil. In these circumstances the question naturally arises whether nitrogen is not a limiting factor in this peat and thereby constituting a major inhibitory factor in its rate of decomposition.

Bacterial Numbers and Organic Matter

If soil micro-organisms play a part in fertility, and it is indubitable that they do, then the slight variations in bacterial numbers when based upon the soil aggregate would indicate no such differentiation between them, (Fig. 1-A). On the other hand when one gram of organic matter is utilized as the base of computation, (Fig. 1-B.), a picture of bacterial numbers is obtained which at once places peat in a direct relationship to its condition of fertility, and offers an explanation of why our semi-arid soils, relatively lower in organic matter, are yet so fertile under their optimum moisture conditions.

Nitrate Nitrogen and Organic Matter

Through the action of micro-organisms on the soil organic matter, nitrate nitrogen is ultimately formed. A disproportionate ratio of carbohydrate to protein in the organic matter will interfere with bacterial activity, and will reflect a lowering of the rate of formation of nitrate nitrogen. If the organic matter is used as a basis of computation, (Table 4.) there is shown to be a rational reason for the high vegetative response of our semi-arid soil, for the *rate* at which nitrate nitrogen is formed from a given quantity of organic matter is double that in the Parkland. What is observed in the higher total nitrates of the latter is the accumulative effect resulting from a larger percentage of organic matter.

Table 4. *Relationship of the soils on basis of ratio of nitrate nitrogen to organic matter per 100 grams soil after 11 weeks incubation.*

Soil Group	Mgs. NO_3-N in 100 grm. soil	Organic matter Per cent. soil	Mgs. NO_3-N per grm. organic matter	Ratio of organic matter to NO_2-N
Timber	16.7	22.22	.75	1,333
Prairie	4.2	7.18	.58	1,724
Park	6.6	27.08	.24	4,166
Peat	2.3	93.13	.025	40,000

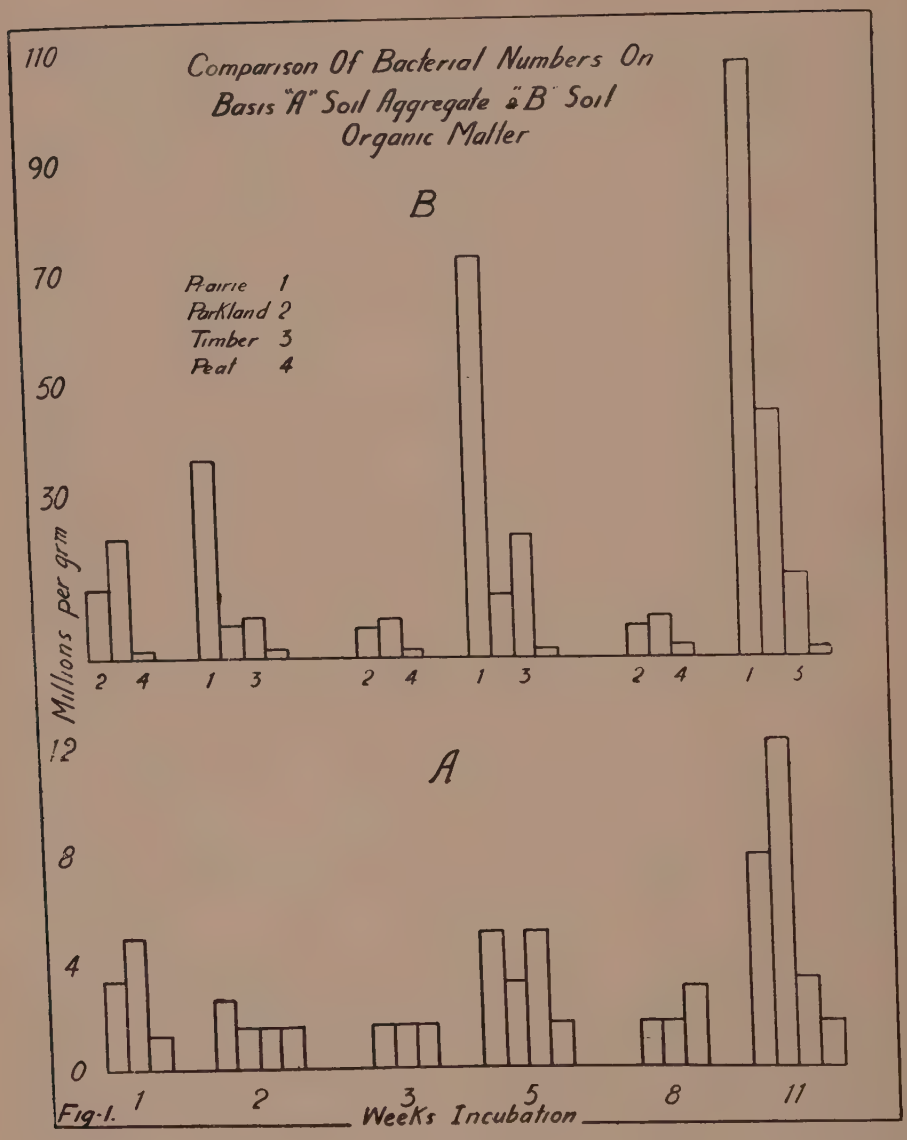

FIGURE 1.

CORRELATIVE FACTORS: ORGANIC MATTER—BACTERIAL NUMBERS—NITRATES

The variations in the organic matter content of the experimental soils preclude using the soils *in toto* for biological measurements for comparative purposes.

The factors, organic matter, bacterial numbers, and nitrates vary in the different soil groups. They are inter-related and complementary to fertility.

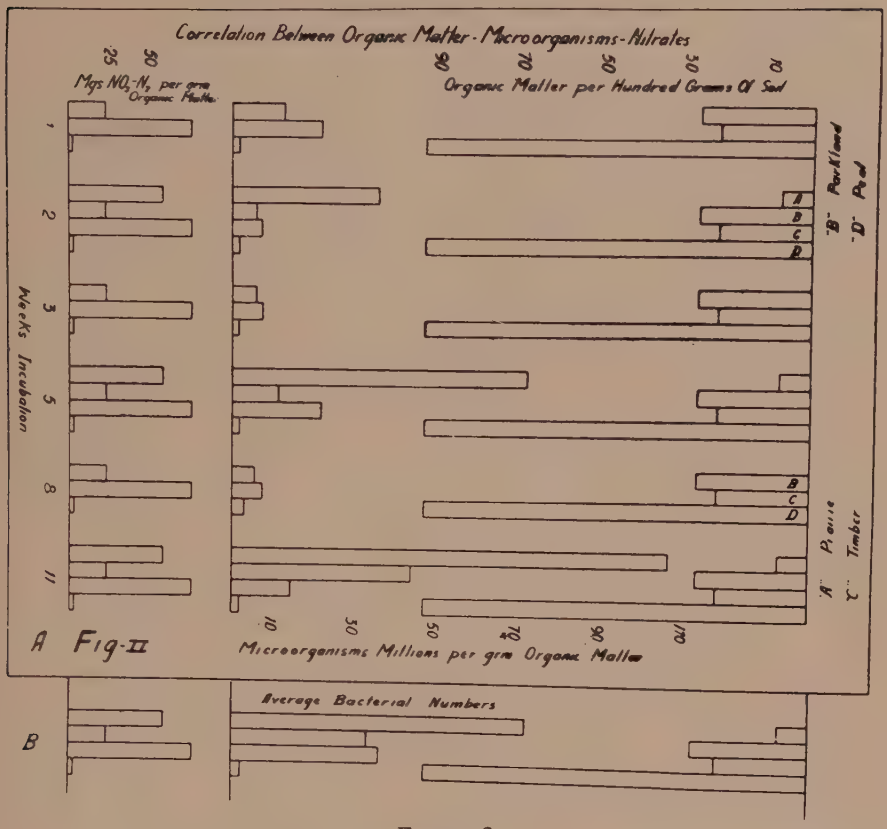

FIGURE 2.

Observation of Figure 2 delineates the fact that bacterial numbers are inversely proportional to the organic matter content and that the rate of nitrification is proportional to micro-organic numbers. The nitrate figures have been computed on the basis of the total quantity accumulated at the end of the experiment divided by the number of weeks of incubation.

The inverse relationship between bacterial numbers per gram organic matter and the total organic matter of 100 gr. soil offers an explanation of why Prairie soils, so relatively low in organic matter, are fertile for a limited period compared to the other soil groups. The rapid decomposition of the organic matter and consequent release of nitrate nitrogen and other salts, is merely a reflection of physiological activity conditioned in the Prairie soil by a greater degree of aeration and enhanced thermal conditions owing to the particular physical structure of its inorganic framework. The degree of utilization of the energy by micro-organisms is intimately bound up with oxygen tension in the soil pore spaces, so that in a soil where the texture is such as to permit of a more rapid interchange of gases resulting from catabolism and those of the atmosphere, the rate of oxidation would be accelerated, other factors being equal. This acceleration would be accentuated the higher the temperature, within certain optima limits. There is then this rather interesting fact, that the greater bacterial numbers in Prairie soil per gram of organic matter partially offsets the apparent

advantage of increased organic matter content of the Parkland and Timber soils.

The writer ventures the opinion that if the vegetative response of the semi-arid soil under ample moisture conditions was unknown, its composition from a fertility standpoint would probably place it in a rather low category, and only by measuring the rate of nitrate formation on the basis of that soil's organic matter content could its value as an arable soil be visualized.

The relative rates of nitrification for each soil at each period of measurement are well maintained, (Fig. 3-B.)

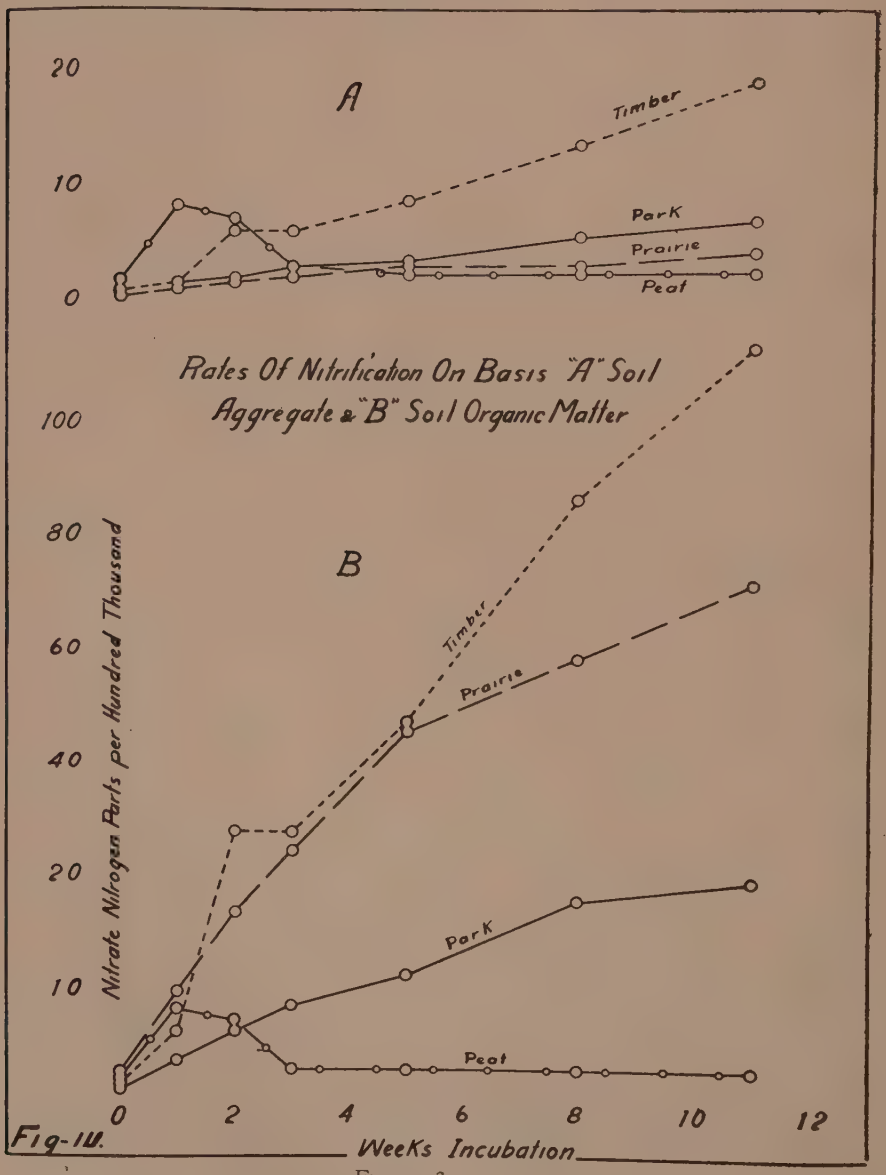

FIGURE 3.

Summary

(1) Samples from four soil groups of Alberta have been subjected to optimum moisture treatment and incubated under laboratory conditions for definite periods of time.

(2) There is shown to be a definite relationship between the organic matter, bacterial numbers and nitrates.

(3) There exists an inverse relationship between the numbers of micro-organisms per gram of organic matter and the total organic matter in one hundred grams of soil.

(4) An explanation involving a fundamental concept in soil bacteriology is suggested to account for the fertility of semi-arid soil. (Prairie)

(5) Experimental evidence supports the fact that nitrogen is a limiting element in the peat under investigation, when measured against the nitrogen content of the organic matter of the mineral soils.

(6) The numbers of micro-organisms of peat and mineral soils are shown to be wholly divergent when calculated upon their organic matter content.

(7) It is evident from these studies that virgin mineral soils of Alberta are well supplied with micro-organisms, that they show a high degree of biological activity, and no dearth of nitrates.

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L'ETAT ACTUEL DE LA QUESTION DES VITAMINES

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(*Traduit par H. M. Nagant*)

Nous traduisons librement les notes suivantes, empruntées à la revue agricole scientifique, de langue neérlandaise: "Onze Ploeg", où elles furent publiées sous la signature de A. Struyf, dans le numéro de Février 1928.

Les techniciens de la Province de Québec, qui ne peuvent rester étrangers aux développements par lesquels passe le problême des vitamines, même s'ils ne sont pas spécialistes en question d'alimentation, y trouveront, nous en sommes convaincus, un résumé clair et au point de la question jusqu'à date. Le problême des vitamines a fait de sérieux progrès au cours des dernières années, malgré les difficultés presque insurmontables d'isoler les vitamines à l'état pur et en quantités suffisantes.

La science est parvenue, sinon à dévoiler le secret de toutes les vitamines, du moins à fournir une interprétation plus ou moins acceptable pour quelques-unes, et même à en isoler une couple avec certitude. Sans vouloir revenir sur la question historique des vitamines et les conclusions pratiques qu'il faut en tirer, principalement en matière d'alimentation, sujet qui fut traité dans maints articles de revue, au cours de la dernière décade, l'auteur se borne à réunir les principaux faits qui ont contribué au développement et à la solution du problême depuis les dernières années, en se plaçant plutot au point de vue de la physiologie générale et avec l'objectif principal de mieux faire connaitre la composition chimique des vitamines. Le concept nouveau des "maladies de carence" avait petit à petit ouvert d'autres horizons dans le domaine de la médecine, surtout dans le cas de tant de maladies et perturbations dans les fonctions vitales, pour lesquelles une explication satisfaisante faisait encore toujours défaut, telles que le rachitisme, certains troubles dans la reproduction, dans l'assimilation du phosphore, dans la reproduction, dans la désassimilation, dans les fonctions nerveuses, certaines éruptions cutanées, etc. De là aussi naquit l'opinion que ces troubles devaient être attribués à l'absence de certains principes stimulants, ou matières vitales, jouissant de la propriété de régulariser les fonctions physiologiques.

On fit des recherches de ces substances susceptibles de faire défaut dans l'alimentation, et bientot on découvrit quelques vitamines nouvelles, tandis que certaines autres déjà connues, furent dédoublées.

Mais à mesure que les recherches et découvertes se multiplièrent, il se produisit bientot, comme c'est le cas ordinaire lorsque de nombreux savants se mettent à travailler un domaine à peine défriché dans différents pays, une certaine confusion dans la nomenclature ou notation alphabétique des vitamines, et actuellement une tendance se manifeste pour établir une classification plus rationnelle des vitamines, basée plutot sur leur comportement vis-à-vis des affections qu'elles préviennent ou guérissent, avec abandon de la notation alphabétique.

Rappel de Quelques Faits

Avant de continuer plus loin, qu'il soit permis de récapituler quelques faits principaux, qui doivent servir de jalons à exposé, depuis les premières découvertes relatives aux vitamines.

En 1897, l'attention du monde scientifique est pour la première fois attirée par des expériences *d'avitaminose* faites aux Indes par le docteur Eykman, qui observe que le béribéri se déclare surtout chez les gens qui se nourissent de riz poli.

L'alimentation de poulets et de pigeons avec du riz poli amène les symptômes d'une affection analogue chez ces animaux. En fournissant du riz entier ou des écales de riz on constate une rapide guérison. Mais on est encore loin de songer que la maladie doit être attribuée au manque d'un principe nécessaire à l'alimentation, et l'opinion est émise que le riz contient un poison dont le contre-poison se trouve dans les écales.

Entre 1900 et 1901 le Dr. Wildiers, de l'Université de Louvain montre que le non développement des levures dans certains milieux de culture est attribuable à l'absence d'un principe nécessaire dans ces milieux. Il donne le nom de "Bios" à ce principe, lequel est observé de nouveau en 1913, par Funk au cours de ses recherches sur la vitamine du Béribéri, et qui le premier la baptisa du nom de "vitamine". Durant la même année une vitamine est repérée par les américains MM. Collum et Davis, dans des expériences d'alimentation de rats avec des substances chimiquement pures, parmi lesquelles nous avons la caséine, le sucre lactose, des corps gras et des sels minéraux. Ces bêtes contractent une affection des yeux, connue sous le nom d'oeil sec ou Xérophtalmie, lorsque la matière grasse qu'elle reçoivent est d'origine végétale ou constituée de suif. L'addition de beurre amène tout de suite une amélioration, d'où il faut conclure que le beurre renferme une substance préventive du mal d'yeux, faisant défaut dans les graisses végétales et le suif.

MM. Collum et Davis donnent le nom de facteur A à cette vitamine, afin de la distinguer de celle de Funk; celle-ci, quoique étant la première à être connue, s'appelle désormais vitamine B.

Observons maintenant qu'au cours des plus récentes recherches sur cette vitamine B, une propriété nouvelle a été mise en évidence, c'est son influence sur la désassimilation des hydrates de carbone. Le manque de vitamine B provoque l'hyperglycémie par suite d'oxydation incomplète des hydrates de carbone, lesquels apparaissent en quantité excessive, sous forme de glucose, (plus de 3 grammes par litre) dans le sang et dans l'urine.

Dedoublement de la Vitamine B.

Plusieurs savants distinguent dans la vitamine B deux substances vitales distincte, lesquelles possèderaient bien certaines propriétés générales en commun, telles que la solubilité dans l'eau, mais manifesteraient cependant des actions spécifiques différentes. Le béribéri, en effet, après les symptômes primaires, tels que la fatigue dans les jambes, le manque d'appétit et d'aptitude au travail, évolue suivant deux formes entièrement différentes: la forme dite sèche, qui se caractérise par toutes sortes de troubles de la sensibilité, tels que démangeaisons, insensibilité, paralysie des membres etc.

Sous cette forme nous avons la polynévrite, caractérisée par la ruine complète du système nerveux.

Une autre forme est celle qui est accompagée d'hydropisie, elle commence par l'enflure des jambes, qui gagne petit à petit tout le corps et va de pair avec une pénible sensation d'étouffement et des vomissements. L'affection provoquée par Eykmann sur ses animaux d'expérimentation avec le régime au riz poli est la forme sèche du béribéri, plus connue sous le nom de polynévrite, (polyneuritis gallinarum, chez les poulets.)

Il est à supposer que nous avons affaire ici avec des avitaminoses différentes suivant que la maladie évolue sous la forme sèche ou hydropique. On connait aussi depuis les premiers temps une troisième vitamine, indiquée par C, qui guérit le scorbut, maladie fréquente chez les gens séjournant de longs mois sur mer et se nourrissant d'aliments conservés.

Comme spécifique on a prescrit le jus de citron. On avait des raisons fondées pour admettre qu'il s'agissait ici également d'avitaminose, d'autant plus qu'on parvient à faire apparaître les symptômes du scorbut chez les animaux nourris avec des aliments stérilisés.

Dedoublement de la Vitamine A.

Il va de soi que ces découvertes stimulèrent beaucoup la curiosité du monde savant anxieux de dévoiler davantage ces mystères insoupçonnés. Bientot de nouvelles vitamines voient le jour, notamment la vitamine D, à laquelle on attribue la cure du rachitisme et qui existe abondamment dans l'huile de foie de morue.

Cette vitamine D n'est qu'un dédoublement du facteur A, qui était déjà noté pour son action triple: régulation de la croissance, action antixérophtalmique et antirachitique.

Il y avait cependant des raisons de supposer que chacune de ces propriétés devait être attribuée à des vitamines spécifiques, toutes solubles dans les corps gras et par conséquent difficiles à séparer les unes des autres. Il était d'ailleurs connu depuis longtemps qu'en l'absence de la vitamine A, la xérophtalmie apparaissait constamment mais qu'il n'en était pas ainsi des symptômes du rachitisme. Lesné et Vagliano démontrèrent que l'huile de foie de morue conservait son action régulatrice de la croissance mais perdait ses propriétés antirachitiques, par injection dans le sang, c'est à dire que le facteur antirachitique était indépendant de la vitamine A. Le beurre, de même que le lait de femme, est dépourvu de vitamine D. L'ingestion d'huile de foie de morue, qui est riche en vitamine D, ainsi qu'on l'a dit, introduit ce facteur dans le lait, et des enfants affectés d'un commencement de rachitisme guérirent après que la mère eut pris de l'huile de foie de morue.

La vitamine suivante est désignée par la lettre E. Elle est également soluble dans les corps gras et on lui attribue un rôle important dans la reproduction. La vitamine E n'est pas présente dans l'huile de foie de morue, mais elle est surtout répandue dans la partie verte des plantes, d'où on peut l'extraire au moyen des dissolvants ordinaires des matières grasses, tel que l'éther par exemple. Son absence dans les aliments détermine l'atrophie des glandes génitales chez le mâle et l'infécondité chez la femelle.

On a encore signalé une vitamine F, et une septième appelée provisoirement P. Cette dernière prémunit surtout contre la "pellagre," maladie qui règne dans les états de L'Europe Méridionnale, l'Irlande et certaines parties

de l'Amérique. L'affection se manifeste surtout par une éruption rouge sur la peau, de l'enflure, le tout accompagné de troubles digestifs et nerveux. Pendant longtemps la cause du mal resta inconnue, récemment elle fut rangée parmi les maladies de carence, comme étant causé par le manque du facteur P. Cette supposition semble d'autant plus fondée que l'on sait que les populations qui y sont sujettes se distinguent par la prédominance des hydrates de carbone, à l'exclusion de la viande, du lait et des légumes frais, dans le régime. On y consomme beaucoup de maïs et de riz.

Il ne semble pas impossible que cette vitamine P fasse partie de la série des vitamines B. Certains savants du moins la rangent dans cette série.

Provisoirement le tableau se termine par la vitamine P.

Composition Chimique des Vitamines

Vitamines azotées et non azotées. Nous devons le mot "vitamine", ainsi qu'il a été dit plus haut, à Funk, qui les considérait comme des substances vitales de composition analogue aux amines, par conséquent des combinaisons possédant le groupe NH^2 dans leur structure moléculaire. Dans la suite, il devint évident que toutes les vitamines ne rentrent pas dans la catégorie des amines, et que plusieurs ne renferment même pas d'azote, cependant le nom resta acquis.

D'autres savants les appellent "facteurs complémentaires de l'alimentation," mais il semble que le nom de "substances vitales" leur convient le mieux, attendu qu'elles ont une part importante dans l'entretien de la vie.

Or pourrait considérer les corps gras, les matières protéiques, les hydrates de carbone et les substances minérales comme formant en quelque sorte le squelette, le corps de l'alimentation, tandis que l'âme en serait représentée par les vitamines, en l'absence desquelles l'organisme dépérit en dépit de l'alimentation la plus riche.

Au point de vue de la composition chimique, on divise actuellement les vitamines en deux groupes:

1o.—*Les vitamines proprement dites,* lesquelles contiennent de l'azote et se décomposent sous l'action des alcalis caustiques (NaOH, KOH). Elles sont solubles dans l'eau et comprennent:

La vitamine B, qui se subdivise en facteur antineuritique et facteur antibéribérique.

La vitamine C, facteur antiscorbutique.

La vitamine P, probablement spécifique contre la pellagre, qui rentre peut-être dans le groupe des vitamines B.

2o.—*Les vitastérines,* sont des vitamines dépourvues d'azote et qui offrent beaucoup de ressemblance avec les *stérines*, un groupe d'alcool supérieurs que l'on trouve en petites quantités dans les huiles et les graisses, dont ils représente une forte proportion de la partie non saponifiable. Elles sont solubles dans les corps gras, et comprennent:

La vitastérine A, facteur antixérophtalmique, la vitastérine D, facteur antirachitique, la vitastérine E, facteur de reproduction. On comprendra que les savants s'efforcent d'isoler complètement les vitamines, de les analyser, de déterminer dans quelles proportions elles interviennent dans les matières brutes, et quelle doit être leur dose nécessaire à l'entretien de la santé.

Funk avait déjà fait des essais d'extraction sur des germes et des écales de riz. De 50 kilogrammes de riz complet, il parvint à extraire, après un laborieux traitement avec des acides, hydrolise et précipitation des albumines au moyen d'acide phospho-tungstique, 0.4 gramme de matière cristalline ne renfermant pas de cendre. C'est à cette substance qui avait la propriété, en très petite quantité, de guérir des poulets malades, qu'il donna le nom de vitamine.

Il fallut attendre jusqu'en 1924, toutefois, avant qu'on apprit quelque-chose de déterminé concernant les séparations chimiques. La nouvelle parvint des Etats-Unis, où on était parvenu à extraire une partie de vitamine B de 400,000 parties de matière première. Des rats malades recevant un trois millionnième de leur poids de cette substance, guérirent en se développèrent normalement. Au point de vue chimique la vitamine B serait apparentée aux dérivés de la pyrimidine, substances qui représentent des produits de dégradation (par hydrolyse) des acides nucléiniques.

On sait que les acides uncléiniques forment en combinaison avec certaines matières albuminoïdes les nucléines, substances phosphorées du noyau de la cellule, de structure extrêmement complexe. Et voila tout ce que nous savons actuellement concernant la composition chimique des vitamines proprement dites.

Mais on est plus avancé dans la connaissance des vitastérines, dont on est parvenu déjà à doser et préparer quelques-unes pour des fins médicales. Il ne sera pas mauvais de dire au préalable un mot des stérines en général, ces *outsiders* qui échappent à la classification régulière que l'on trouve dans les manuels de chimie organique courants, et sont de ce fait ignorées de ceux qui ne sont pas des fervents de la chimie.

Les stérines forment un groupe d'alcools à poids moléculaire élevé, de structure cyclique (ou aromatique) qui acompagnent toujours en petites quantités les graisses animales et végétales. Dans le premier cas elles forment les cholestérines, dans le deuxième les phytostérines. Les deux classes se distinguent par des formes cristallines différentes, ce qui permet de les reconnaitre les unes des autres au moyen du microscope, et par la même de distinguer les graisses végétales des graisses animales dans leurs mélanges éventuels. (Par exemple, en cas de falsification du beurre naturel par du beurre de coco.)

La cholestérine ordinaire, à laquelle on attribue la formule brute C_{27} H_{46} O, est un alcool monoatomique, non saturé, se trouvant sous forme d'éther de l'acide palmitique dans le suint de mouton et dans les graisses et huiles animales en général. On la rencontre encore dans le jaune d'oeuf, dans les tissus nerveux, le sang, et elle forme chez l'homme, dans les plupart des eas, la substance des douloureux calculs billiaires, d'où on peut l'extraire en grande quantité.

Dans le groupe des Phytostérines, il y a à mentionner la Sistostérine (ou phytostérine ordinaire), que l'on peut retirer des germes des céréales, des huiles de lin, de mais, de sésame, du beurre de cacao, etc. Sa composition se rapproche de celle de la cholestérine et elle cristallise en forme d'aiguilles fusibles à 138°.

De plus, on connait encore la Stigmastérine, phytostérine fusible à 170°, existant dans l'huile de navet, qui renferme aussi la Brassicastérine, matière entrant en fusion à 148°. Dans la levure de bière, on trouve de l'Ergostérine, dont on connait aussi un isomère.

Methode d'Extraction des Sterines

On commence par saponifier les matières grasses dans lesquelles elles se trouvent, au moyen d'une solution alcoolique de potasse caustique, sur bain-marie bouillant. Après saponification, la solution de savon est traitée avec de l'eau chaude, acidulée de HCl; lorsque les acides gras se sont réunis à la surface, sous forme d'un liquide clair, on filtre à chaud. Les acides gras restant sur le filtre sont réchauffés à la température de 70° et traités au moyen d'une solution alcoolique de Digitoline. Après quelques temps, il se produit un précipité formé d'une combinaison de Digitoninestérine.

Lorsque la précipitation est complète, il s'agit d'y ajouter du chloroforme dans le but de dissoudre les graisses. On sépare ensuite la solution par filtration et on conserve la digitostérine sur le filtre. On peut en extraire la stérine à l'état pur, par le chauffage prolongé avec du xylol.

Considerations Sur Quelques Vitasterines

Nous devons la découverte de la vitastérine A, régulatrice de la croissance, à un Japonais du nom de Tahakaski, qui sépara de l'huile de foie de morue (ainsi que des épinards), une huile rouge-jaunâtre, d'odeur non désagréable. Cette huile, qui très stable et se laisse facilement distiller dans le vide, a reçu le nom de Biostérine. On a trouvé qu'un gramme de Biostérine dans 1000 grammes de nourriture suffit pour entretenir la croissance normale chez les rats.

Le professeur Windaus est parvenu à isoler la vitastérine D, antirachitique.

Autrefois on prescrivait comme remède principal contre le rachitisme, l'huile de foie de morue. Graduellement cependant, l'emploi des rayons ultra-violets entra en vogue, surtout à cause de la rapidité de l'amélioration constatée. On fit aussi des essais avec des aliments soumis à ces radiations et on acquit bientot l'expérience que les plantes et les tissus des animaux acquéraient des propriétés antirachitiques sous l'influence des rayons ultra-violets. De même il fut constaté que l'ergostérine (phytostérine existant dans la levure de bière, ainsi qu'on l'a vu plus haut) fournit sous l'influence des radiations dans le vide un isomère possèdant de fortes propriétés antirachitiques.

Mais tandis que la cholestérine brute acquiert des propriétés antirachitiques lorsqu'on la soumet aux radiations ultra-violettes, il n'en est pas de même de la cholestérine chimiquement pure; il faut en conclure que la cholestérine brute renferme de petites quantités d'ergostérine qui sous l'action des radiations acquiert les propriétés mentionnées. Et, de fait, on est parvenu à extraire par distillation de la cholestérine brute, dans le vide, l'ergostérine parfaitement identique à celle de la levure de bière.

Ceci ne fut pas seulement confirmé par voie chimique mais encore par les méthodes physiologiques, notamment par la guérison de rats rachitikues. Un millionnième de gramme par jour amena la guérison des rats au bout de trois semaines.

L'exposé s'arrête ici parce que les vitastérines A et D sont les seules qui aient été découvertes et isolées jusqu'aujourd'hui. Les recherches se poursuivent naturellement avec ardeur, principalement en Allemagne, en Angleterre et aux Etats-Unis, et on peut s'attendre à nouvelles surprises dans un avenir rapproché.

Par la mise en liberté des vitastérines, le probléme est entré décidément sur un terrain pratique. Il est vrai qu'autrefois déjà, des aliments, soidisant "a base de vitamines" obtenus au moyen de mélanges appropriés, furent mis dans le commerce, mais il y avait bien des raisons de douter de leur valeur en tant que vitamines, parce qu'il s'agissait plus ici de faire de l'argent avec des tîtres ronflants que le rendre un réel service.

Actuellement cependant, avec la facilité d'obtenir le facteur antirachitique, pour ne mentionner que celui-ci, nous pouvons espérer atteindre des résultats tangibles tant au point de vue commercial que médical.

Dans le domaine commercial, par exemple, on pourrait proposer de préparer la margarine, qui est dépourvue de la vitamine D, en lui incorporant la quantité voulue d'ergostérine traitée par les rayons ultra-violets. Ainsi serait donc comblée une lacune dans la composition de la margarine. Mais en raison des quantités considérables d'ergostérine que cette préparation exigerait, la solution du problême ne semble pas rentrer dans les possibilités immédiates.

Dans le domaine médical toutefois, l'emploi d'ergostérine traitée par les rayons semble devoir être réalisé bientot, parce qu'il ne s'agit ici que de petites quantités, faciles à obtenir.

Pourtant, jusqu'ici, les préparations artificielles n'ont été appliquées avec succès que sur des animaux d'expérimentation.

Pour faciliter la lecture de l'exposé qui précède, nous faisons suivre ce petit tableau-résumé.

CLASSIFICATION PROVISOIRE DES VITAMINES

Vitamines A. (Stérines)
- Facteur antixérophtalmique (Vitastérine).
- Facteur régulateur de la croissance (Biostérine).
- Facteur D, antirachitique (Ergostérine et isomère).

Dans l'huile de foie de morue.

(Dans la levure de bière, mais non dans le gras du lait.)

Vitamines B. (Amines)
- Facteur antinévritique (forme sèche du Béribéri.)
- Facteur antibéribérique (Forme hydropique du Béribéri.)
- Facteur P, antipellagre (Fait peut-être partie du groupe B.)

Dans le riz.

Vitamine C. Antiscorbutique.

Dans le jus de citron.

Vitamine E. Facteur de reproduction.

(Soluble dans les corps gras.)

Dans la partie verte des plantes.

Vitamine F.

ACTIVITES DES SECTIONS

Section de Ste. Anne de la Pocatiere

M. Georges Bouchard, délégué officiel du Canada au "Congrès International des Arts Populaires" à Prague, nous a entretenus de sa mission au pays des Tchèques, à la séance au 12 Décembre.

M. Bouchard nous a décrit par la parole et par la démonstration les habitudes des paysans de ces pays. A la fin, il nous a fait voir des objets de ces pays où les gens ont naturellement le goût des dessins brillants et des couleurs voyantes; mais ces gens de Bohême savent tirer un effet rutilant des couleurs, en dessinant très finement leurs modèles d'après leur propre inspiration.

Tabliers, coiffes, jupons, etc., M. Bouchard en a fait une collection touchante. Même une chemise des dimanches pour hommes au sujet de laquelle un agronome a fait la remarque qu'elle pouvait bien être un peu..... courte, a attiré l'admiration unanime.....

Les Tchèques sont en outre des décorateurs nés et ils prennent plaisir à renouveler souvent les décorations extérieures et intérieures de leurs maisons, d'après un plan général, mais également d'après le goût de celui qui décore.

On ne semble pas connaître le modèle fixe, pas plus que la fabrication en série. C'est un peu comme chez-nous, où nos fermières les plus avisées ont une manière bien personnelle de dessiner leurs travaux.

M. Bouchard a conclu que la Province de Québec possède des trésors en art populaire et domestique et que si l'on peut perfectionner un peu l'exécution, le plan général fixé par nos habitudes et le bon goût des canadiennes devrait rester ce qu'il est.

Perfectioonner n'est pas substituer.

Le plus important pour le moment est de ne pas perdre l'habitude de ces travaux domestiques et populaires qui peuvent devenir une partie importante de l'économie du tourisme que nous voulons développer chez-nous.....

Le conférencier présenté par le l'Abbé Jean, Professeur, et président de la section de Sainte-Anne, fut remercié par M. Hector Leblanc, Agronome de Maria.

Les étudiants en Agriculture furent aussi représentés à cette réunion par les officiers de la classe des finissants de 1928, MM. Omer Allard, Gérard Lagacé, Gérard Dumont et E. Tremblay.

E. C.

Notes

Nous adressons nos sincères sympathies au confrère Gustave Toupin, Secrétaire de la Section de Montréal, qui a été douloureusement éprouvé par la perte de sa mère, décédée le 12 janvier à Saint Isidore de Laprairie.

Monsieur Nazaire Parent (Laval '26) du bureau de l'Entomologie, Ministère de l'Agriculture, Québec, qui s'occupait jusqu'ici de la lutte contre la pyrale du maïs, a pris charge de la comptabilité des fermes de démonstration, au Service de la Grande Culture. M. Parent succède à M. D. Belzile nommé récemment Assistant-surintendent des fermes d'illustration à Ottawa.

CONCERNING THE C.S.T.A.

Between January 17th and January 26th, the President and General Secretary attended local branch meetings at Macdonald College, Fort William, Winnipeg, Regina and Saskatoon. The President, Dr. E. S. Archibald, also addressed the members of the Eastern Ontario local at Ottawa on January 18th, and continued the western trip to attend branch meetings at Edmonton on January 30th, Summerland, B.C., on February 7th, and Vancouver, B.C., on February 11th or 12th.

At the meetings referred to above there was a total attendance of over two hundred members, and they took advantage of the presence of the President and General Secretary to enter into a general discussion of Society affairs. Prior to these discussions, the General Secretary had dealt with the history of the C.S.T.A. from the time of its organization in 1920 up to the present year, referring particularly to (1) membership, (2) finances, (3) the development of the journal, (4) the increase in recognition given to the Society and (5) some of its immediate needs. Dr. Archibald then outlined what, in his opinion, should be the lines along which further extension should be made. He stressed the importance of active local branches, energetic standing committees and the development of group organization and affiliations within the parent Society. By development along these lines, the annual convention would become a clearing house for the work and recommendations of locals during the year, the standing committees would function continuously and their reports would embrace the opinions of a large majority of the members. The annual meeting would, except for these business sessions, be given over to specialized groups of members and to affiliated Societies which would arrange their own programmes.

Owing to the fact that a number of members were unable to attend the meetings arranged for the President and General Secretary, and also because some locals found it impossible to arrange meetings at suitable dates, it is probable that a small booklet will be prepared and mailed to every member in the near future. Such a booklet should serve as a useful reference and might bring before the next convention a number of helpful suggestions.

At the Ottawa meeting on January 18th, a debate was held on the question: "Resolved that the officers of the Dominion Department of Agriculture should not undertake field or extension work as relating to agricultural production, but should recognize that such activities properly come under the direct control of provincial agencies." The negative side, supported by Messrs. H. S. Arkell and T. G. Raynor, defeated the affirmative side, supported by Messrs. G. H. Clark and H. L. Trueman.

Tentative Convention Programme

The dates for the Ninth Annual Convention, to be held at the Manitoba Agricultural College, Winnipeg, have been definitely fixed—June 12th to 15th inclusive, 1929. The mornings of June 13th, 14th and 15th will be given over to business sessions with an open lecture each morning at 11

o'clock. The afternoons of June 12th, 14th and 15th will be occupied with group meetings and lectures. A motor excursion to the Dominion Experimental Station at Morden has been arranged for the afternoon and evening of June 13th..

It is anticipated that group meetings will be arranged in Agronomy, Animal Husbandry, Economics and Horticulture, the first two under the auspices of the Western Canadian Society of Agronomy and the Western Canada Society of Animal Production respectively, and the last two under the Economics and Horticulture groups of the C.S.T.A.

The President and General Secretary met a special committee of Manitoba members in Winnipeg on January 22nd and the following convention committee chairmen were appointed: Publicity, Mr. George Batho; Entertainment, Mr. J. H. Evans; Reception, Mr. J. H. Ellis; Programme, Dean W. C. McKillican; Registration, Mr. Norman James. Each Chairman will add such other members to his committee as circumstances warrant.

Arrangements for a Civic welcome, a complimentary luncheon by the Manitoba branch of the C.S.T.A. and a banquet by the Provincial Department of Agriculture, are being made, and free periods are being allowed for informal meetings and recreation.

Notes and News

J. B. Munro (Toronto '19) has been appointed Deputy Minister of Agriculture for British Columbia.

H. L. A. Tarr (British Columbia '26) has registered for the Ph.D. course in Bacteriology, with minor in Biochemistry, at McGill University.

A. Ste. Pierre (Laval '22) has changed his address to Ste. Anne de la Pocatière, P.Q.

Antonio Besner (Montreal '23), who has been Assistant County Agriculturist at Village Richelieu, P.Q., has been transferred to Matane, P.Q.

E. L. Eaton (Toronto '20), formerly Agricultural Representative at Lawrencetown, N.S., has been appointed Professor of Agronomy and Farm Superintendent at the Agricultural College, Truro, N.S.

J. W. Graham (McGill '22), District Sheep and Swine Promoter under the Dominion Live Stock Branch at Truro, N.S., has been transferred to Moncton, N.B.

J. Laughland (Toronto '10) has resigned his position as Agricultural Representative for Lennox and Addington County, Ont., and has been appointed to the staff of the Department of Field Husbandry at the Ontario Agricultural College, Guelph, Ont.

G. A. Luyat (British Columbia '27) has been appointed District Agriculturist with headquarters at Williams Lake, Cariboo, B.C.

G. R. Lane (Toronto '24), formerly Superintendent of the Ontario Provincial Forestry Station at Midhurst, has accepted a position as Assistant to the Chief Forester and Forester in Charge of Reforestration, Laurentide Division of the Canada Power and Paper Corporation at Grand Mere, P.Q.

E. A. Howrie (Saskatchewan '23) has been appointed Principal of the High School at Eskbank, Sask.

Graduate Scholarships

On the opposite page, we have reproduced photographs of the five C.S.T.A. members who were awarded the T. Eaton Company graduate scholarships in June, 1928, and are now pursuing their advanced studies. A brief statement regarding these men may be of interest:

R. C. Russell received his B.S.A. degree from the University of Saskatchewan in 1924. He was engaged as laboratory assistant in the Dominion Laboratory of Plant Pathology at Saskatoon during the winter of 1924-25, and was appointed Assistant Plant Pathologist in August, 1925, a position which he still holds. He took up graduate work at the University of Saskatchewan in the fall of 1925 and received his M.S.A. degree from that institution in 1926. He is now taking work towards his Doctor's degree in the Department of Botany at the University of Torotno, applying himself particularly to a study of "take-all," one of the most formidable of the root rots of wheat in Western Canada.

R. H. Bedford obtained his B.Sc. in Agriculture at the University of Alberta in 1926. During the following two years he took up graduate work at the same institution and at the same time was engaged by the University in making a preliminary biological survey of soils under different crops. He was awarded the degree of M.Sc. from the University of Alberta in 1928. He is now taking further graduate work in the Bacteriology Department of McGill University, devoting special attention to the study of soil micro-organisms and their influence upon plant life.

F. E. Foulds graduated from McMaster University, Toronto, in 1916 with the degree of B.Sc. (Agr.). He was overseas until 1918, attended the College of Education, Toronto, during 1918-19 and taught science and agriculture at the Clinton Collegiate Institute until the end of 1920. He was then appointed Supervising Analyst in the Dominion Seed Branch Laboratory at Winnipeg, and still holds that position. He is now taking graduate work in the Botany Department of the University of Toronto, applying himself particularly to a study of the morphological characters of seeds of Agropyron in order to secure means of identification. One species (western rye grass) is one of the best hay crops of the west, another (couch grass) is probably Canada's worst weed, and there are at least 25 other species growing wild on the prairies which vary from fairly serious weeds to beneficial pasture plants.

Auguste Scott is a French-Canadian who received his B.A. degree from the University of Montreal in 1924 and his B.S.A. degree from Laval University in 1927. He was an assistant county agriculturist at Plessisville, P.Q., during the summer of 1928. His graduate work is being taken in soil chemistry at the Ontario Agricultural College, under the Faculty of Graduate Studies of Toronto University. A soil classification is needed in Quebec and soil surveys were undertaken in Ontario some fifteen years ago. Mr. Scott hopes to increase his usefulness to the Province of Quebec by his studies at Guelph under Professor Harcourt.

F. J. Richardson graduated from the University of Toronto, (Ontario Agricultural College) in 1926 with his B.S.A. degree. He was engaged with

AWARDED THE T. EATON COMPANY SCHOLARSHIPS FOR 1928.

1, R. C. Russell; 2, R. H. Bedford; 3, F. E. Foulds; 4, Auguste Scott; 5, F. J. Richardson.

the Poultry Department of the O.A.C. on extension work during 1926-27 and took advanced work under a research project of the Empire Marketing Board the following year. His graduate work under the T. Eaton Company scholarship is being taken in the Poultry Department of the O.A.C., under the University of Toronto. His studies apply particularly to the condition in poultry which is loosely termed "leg weakness of chickens," which, together with paralysis and other conditions, represents a fundamental difficulty in economical growth, production and reproduction.

Applications for the 1929 T. Eaton Company Scholarships may be sent to the General Secretary of the C.S.T.A. at any time before May 15th next. Regular application forms will be sent to any member of the Society on request. Five scholarships of $600 each, tenable at any Canadian University, are available and will be awarded by a special committee at the Winnipeg Convention next June.

When the five 1928 scholarships were awarded last June, a recommendation was made that steps be taken to secure additional scholarships from other commercial firms and corporations, so that more qualified candidates might be assisted in the continuance of their studies. Last year there were eighteen deserving candidates for the five available scholarships and it is anticipated that there will be a larger number of applications this year. There is a possibility that more scholarships may be available, but no announcement to that effect can yet be made.

Applications for Membership

The following applications for regular membership have been received since January 1, 1929:—

Acheson, S. C. (Manitoba, 1928, B.S.A.) Winnipeg, Man.
Allard, Omer (Laval, 1928, B.S.A.) Weedon, P.Q.
Beaudry, Julien (Laval, 1907, B.A.) Amos, P.Q.
Brookins, W. W. (Toronto, 1924, B.S.A.; Nebraska, 1928, M.Sc.) Goodwell, Okla, U.S.A.
Cockburn, W. M. (Toronto, 1923, B.S.A.) Carp, Ont.
Gilbert, A. H. (Vermont, 1904, B.Sc.) Macdonald College, P.Q.
Hébert, Aurèle (Laval, 1927, B.S.A.) Rimouski, P.Q.
Hilton, G. C. (Maine, 1924, B.S.; Michigan State College, 1926, M.S.) Macdonald College, P.Q.
Larmour, R. K. (Saskatchewan, 1923, B.Sc.; Saskatchewan, 1925, M.Sc.; Minnesota, 1927, Ph.D.) Saskatoon, Sask.
North, F. G. (Toronto, 1923, B.S.A.) Macdonald College, P.Q.
Pugsley, L. I. (Acadia, 1927, B.A.) Macdonald College, P.Q.
Quayle, W. C. (Liverpool, 1912, B.Sc.; Cambridge, 1924, M.A.) Macdonald College, P.Q.
Tremblay, L. A. (Laval, 1928, B.S.A.) Ste. Anne de la Pocatière, P.Q.
Williams, E. K. (McGill, 1923, B.S.A.) Macdonald College, P.Q.